THE

FOUNDRY TRADE JOURNAL

WITH WHICH IS INCORPORATED

THE IRON AND STEEL TRADES JOURNAL

VOL. 56 Thursday, June 24, 1937 No. 1088

PUBLISHED WEEKLY

Subscription Terms : 15s. per annum.
Foreign and Colonial : 17s. 6d. per annum.
All Subscriptions are payable in advance.

All Communications to be addressed to the Editor, the Advertisement Manager, or the Publisher of

THE FOUNDRY TRADE JOURNAL
49, WELLINGTON STREET, LONDON, W.C.2

Telegraphic Address : "Zacatecas, Rand, London."
Telephone : Temple Bar 3951 (5 lines).

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF

The Institute of British Foundrymen

The Institute of Vitreous Enamellers

The Welsh Engineers' and Founders' Association

and

The Foundry Trades' Equipment and Supplies Association

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Foremen

The modern tendency is for the larger firms to engage an employment manager, who is responsible for providing the various departments with its staff. The earlier system was for the managing director to engage the managers, the managers the foremen, and the foremen the operatives. The advantages claimed for the newer systems are that (1) the employment manager is a specialist in his line and (2) nepotism is automatically eliminated. Neither of these two factors impresses us as being of paramount importance and we are of the opinion that the older method has much to commend it. If a foreman is to be responsible for the conduct of his shop, the fact that he is his own labour manager is helpful in maintaining discipline. If he does engage relations there is still the manager to see that no favouritism is displayed. The idea that a foreman should only be responsible for output is gaining ground, but here again we would prefer that the services of a production engineer be called in, and retain for the foreman his responsibility for engaging his own labour force. If he can do both so much the better. We are aware that in certain factories the services of an employment manager have won the unstinted approbation of the whole of the staff, but in others there is a feeling in every department that the foremen are being supplied with industrial misfits.

Modern manufacturing conditions throw too much work on the shoulders of the foreman and relief is often given to him in a manner which undermines his authority. The last method to be adopted, and yet it is the most obvious, is to give the foreman an assistant. In the foundry industry, we suggest that the best assistance that can be given to the foreman is by providing him with a college-trained metallurgist. This assistant would help with production-planning, costing, technical control, and liaison with the drawing office and laboratories. The charge hands of the various sections of the floor will effect the necessary contact with the operatives. To restrict in any way the authority of the foreman is to retrograde action. He is one recognised by the workmen as occupying a position worth striving after, and the more important that position can be made the better will be the general outlook on industrial life by the operative. It is impossible to differentiate in many cases between the title of foreman and manager, but the above remarks are intended to apply to men who take full responsibility for the conduct of a shop manufacturing castings.

An American Opinion

We are so accustomed in this country to regard the United States as a land flowing with milk and honey, as far as research is concerned, that it comes as a pleasurable surprise to read the opinions of prominent American industrialists on British research institutions. The general view is that in this country we have plenty of first-class men, but an unwillingness to use the results of science in industry, and that our men have to manage with inadequate backing in material and equipment. On the other hand, it is common to regard the United States as liberal in provision for science in industry and as having some remarkable foundations endowed by wealthy men for prosecuting scientific research. Some forty American business men have just toured this country to see for themselves the provision made for research, and they summarise their views as follows. Britain is well abreast of the most modern methods for both pure and applied science. British industry is preparing for the future, and research is everywhere a major factor in industrial planning. Although most of the laboratories visited were admirable in equipment and lay-out, marvellous results have been obtained by British research workers using relatively small laboratories and crude equipment.

In commenting on these views, and in particular the large amount of leeway we have had to make up in comparison with other nations, stress has been laid on the individualism of the British manufacturer, which makes it more difficult to pursue costly research than where co-operation is more practised, and upon the free trade system which prevailed until recently. The vulnerability of the British market made it difficult to lay out the funds for research. This drawback is happily removed, and the greater security of the home market will doubtless encourage even the most strongly individual manufacturer to contribute his quota to co-operative schemes. Compared with aggregate expenditures on education, defence, advertising, and so on, the money required to make the rest worth while is negligibly small.

The British Non-Ferrous Metals Research Association

ANNUAL MEETING AND LUNCHEON

The annual general meeting and luncheon of the British Non-Ferrous Metals Research Association was held at the Grand Hotel, Birmingham last Tuesday. At the luncheon Lieut.-Colonel J. H. M. Greenly, the new chairman, paid tribute to the work of Mr. T. Bolton, who since the foundation of the Association 17 years ago, until his death recently, was its chairman. He said that to-day, when all are mourning his loss, it is realised perhaps more than ever what a great debt of gratitude was owing to him for the time, work, energy and enthusiasm which he put into the work, so important to the great non-ferrous metal industries of this country. There can be no better memorial to his memory than for work started so ably and carried on with such success to be continued.

Present Position

COLONEL GREENLY, speaking of the present position of the Association said that for many years the industries of this country lagged somewhat behind those of Continental nations in their enthusiasm for research, but to-day it would be equally true to say this country has become very much more research-minded. At the present time the British Non-Ferrous Metals Research Association had a membership of 256. In the country some 3,000 concerns dealt directly in the production, manufacture and use of non-ferrous metals, 6,500 other firms were connected in one way or another with the non-ferrous metals industry; and a further 1,200 undertakings dealt in non-ferrous metals. It would not be straining the point too far to say that every one of those concerns benefited by the work of the Association, which was doing a work of such national importance that it should commend itself to the support of all who benefited by it. Approximate figures showed that the total world consumption of non-ferrous metals annually was 5,487,000 tons. In the United Kingdom imports totalled 890,000 tons, and production accounted for a further 157,000 tons, representing a United Kingdom total of more than 1,000,000 tons of an approximate value at present-day prices of £55,155,000.

In conclusion Colonel Greenly said that it was of fundamental importance that unless the scientist made his finds intelligible to the ordinary industrialist he loses half the value and object of his work.

SIR FRANK SMITH, secretary of the Department of Scientific and Industrial Research, discussing the progress of research since the turn of the century, urged the importance of pure research as well as that of applied research. This country, he continued, has got to be pre-eminent in industry if its population was to live. Unless exports were sold, the hundreds of millions of pounds worth of food could not be imported.

THE LORD MAYOR OF BIRMINGHAM paid a tribute to the work of the Association, which he reminded his listeners, was founded in Birmingham.

Correspondence

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—With reference to my letter to you which you published under the title of "A Recruitment Problem," I have to thank you for the unbiassed editorials which have appeared on the subject. The main point, I think, when the whole thing is boiled down, is, that the foundry has no right to cry out for technically and practically trained men if it does not give an opportunity for technical men to receive practical training.

There are, of course, plenty of apprenticeships for boys from 14 or 16 to 21, but at the age of 16 a boy cannot know whether he should take such an apprenticeship or not, and in consequence there are many men of adequate theoretical training who wish to join the foundry trade. There are few of these men who can afford to work for, say, 6 months or 1 year as an apprentice for apprentice wages at their stage of life.

Yours, etc.,

"QUALIFIED."

[This letter has been considerably reduced.—EDITOR.]

Institute Elects New Members

At a meeting of the Council of the Institute of British Foundrymen, held recently in the Assembly Rooms, Market Place, Derby, the following were elected to the various grades of membership.

As Members.

J. Bamford, B.Sc. Eng., lecturer in charge, British Foundry School, Birmingham; Major R. A. Briggs, managing director, Qualcast (Aust.) Proprietary, Limited, Melbourne; E. A. Carlisle, representative, W. Cumming & Company, Limited, London; N. Carter, representative, General Refractories, Limited, Sheffield; J. P. Ibbotson, manager, United Steel Companies, Limited, Sheffield; T. F. Pearson, M.Sc., research investigator, British Non-Ferrous Metals Research Association, London; W. T. Robotham, foundry manager, Clissold Foundry, Spring Hill, Birmingham; W. B. Sallitt, mechanical engineer, Copper Development Association, London; G. P. Tinker, assistant to the general manager, Birmingham, Electric Furnaces, Limited; L. C. Trevelyan, B.A., metallurgist, Brown-Firth Research Laboratories; G. F. Williams, works manager, Coalbrookdale Company, Limited, Coalbrookdale.

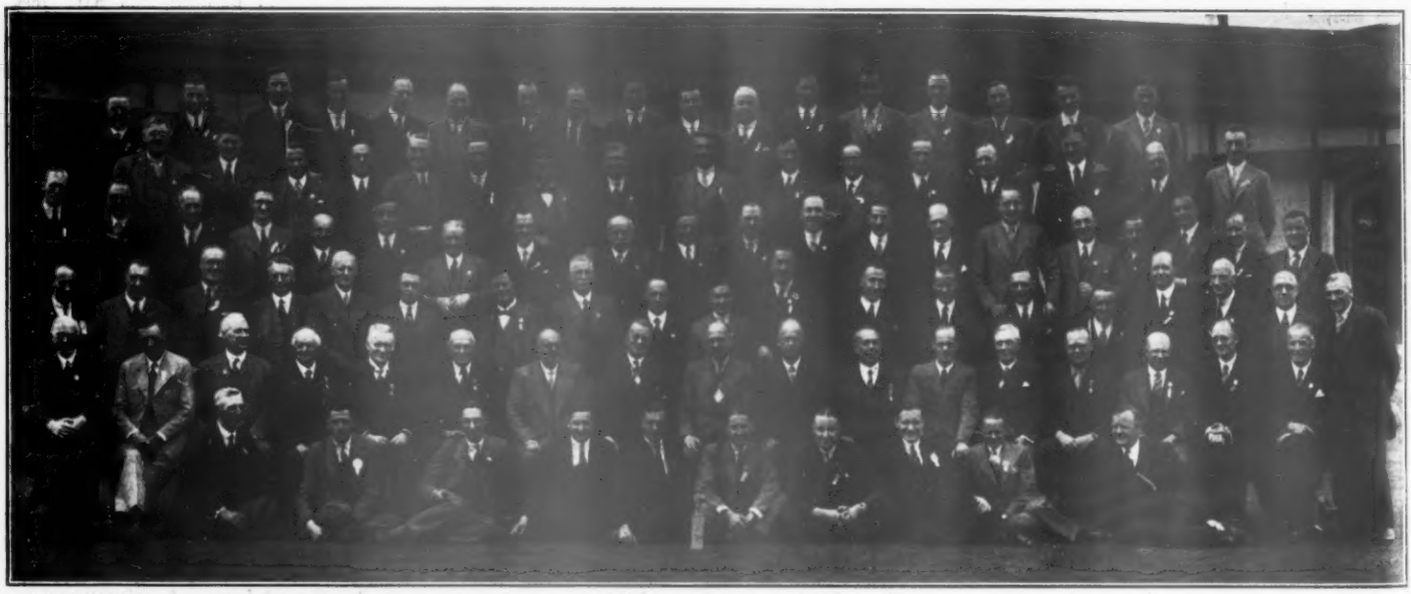
As Associate Members.

G. R. Harvey, assistant manager, G. Harvey & Company, Limited, Chapeltown; J. Ross, foreman patternmaker, Fullwood Foundry Company, Limited, Mossend; J. T. Sreyd, moulder; J. E. Stokes, B.Sc. Eng., engineer, Sheepbridge Stokes Centrifugal Castings Company, Limited, Chesterfield; C. Y. Tien, B.Sc., M.Sc., transport manager, Highway Administration, Anhwei, China.

As Associate.

C. Huyton, moulder, Craven Bros., Limited, Reddish.

IT WAS ANNOUNCED in the House of Commons last Tuesday that a company is to be formed with a capital of £1,000,000 to build and operate a steel plant at Jarrow. The chairman is to be Mr. G. Bruce-Gardner. The scheme has been made possible by a grant from the fund created under the Special Areas Act, 1937, and the co-operation of the Bankers' Industrial Development Company, the Nuffield Trustees and the Consett Iron Company, Limited.



MEMBERS OF THE INSTITUTE OF BRITISH FOUNDRYMEN PHOTOGRAPHED AT THE WORKS OF QUALCAST, LIMITED, WHICH THEY VISITED DURING THEIR ANNUAL CONFERENCE IN DERBY.

Notes on the Structure and Characteristics of Aluminium Alloys*

By H. C. HALL, M.Met., F.I.C.

There is a considerable volume of published research dealing with the properties of cast alloys of aluminium. Much of it is, however, very specialised and theoretical, and its application to normal foundry practice is not very obvious. In this Paper it is proposed to discuss some of the properties of aluminium alloys, making a survey of present knowledge, with particular reference to structure, life and physical strength.

Although the ultimate nature of molecular structure of metals is of fundamental importance, governing as it does the specific gravity, modulus of elasticity and general characteristics, no attempt will be made to penetrate into this still controversial subject. Initially, it is proposed to consider what happens when a pure metal solidifies in a mould. As is well known, the metal starts crystallising from various centres or surfaces when it has cooled (about 660 deg. C. in the case of pure aluminium).

The grain size of metals and alloys of a particular composition and cast under particular conditions is extraordinarily constant, as is indicated by fracture and micro examination. This may be partly due to characteristic grouping just prior to, and during solidification. Also, it appears that when there is a considerable solid solution of one metal in another the greater affinity between them results in either a greater number of crystals in a given volume, or marked dendritic tendency due to more gradual solidification. The latter is also observed when a pure metal solidifies in the presence of a considerable proportion of a constituent of much lower melting point.

In the case of aluminium the macro structure is not much affected by eutectics or compounds which largely make up the cell walls of the micro structure. If an alloy of aluminium containing only a small amount of metal capable of being retained in solid solution is rapidly cooled from a temperature considerably above its melting point, very large macro crystals are generally observed.

H. C. HALL, M.MET., F.I.C.

In the case of aluminium containing 1.4 per cent. iron, 0.3 per cent. silicon, the large crystalline structure as shown by macro etching in Fig. 1, is found on micro examination to have a detail form, such as is indicated by Fig. 2. Slower cooling as the result of casting in a sand mould generally promotes crystallisation from numerous centres without the development of sufficient energy in a given time to permit an extended orderly arrangement, *i.e.*, large macro crystals made up of units with predominant axial tendencies (Fig. 3).

Fig. 4 shows the usual so-called idiomorphic crystals of irregular external, but with definite internal symmetry or packing as indicated. The dark line across the illustration is where the section shown in the upper half meets with the lower half section at right angles. A suggests the possible production of a cube by "splitting off" parts of an idiomorphic crystal along cleavage planes. B shows a crystal with subsidiary crystals, these having slight variation in crystal orientation relative to each other, owing to impurity or internal stress, after solidification has taken place. E shows the impurity ejected to the cell walls.

The crystalline axes or cleavage planes of adjacent crystals may be different, as shown in the case of D and C. The etching is generally greater if a plane happens to be at a certain inclination to the surface—as indicated on the lower part of the illustration, or the amount of attack may depend on electrolytic effect; neighbouring crystals having a potential difference due to variation in individual orientation. The resulting steps at crystal junctions show up as a line on microscopic examination.

One may conclude that molecular packing is closest inside the cells. This is generally confirmed by controlled density estimations—eliminating other variables as far as possible—and the more cell walls there are in a unit volume the lower is the density. In aluminium, crystal-growth may take place easily, two or more cells becoming one by simple annealing; this confirms the theory that the boundaries are not in the nature of ultra-microscopic oxide films since in the case of aluminium such would resist solid diffusion owing to its impermeable nature.

The strength of the structure depends both on cohesion between the constituent crystals at the cell walls and also on the cohesion at crystal cleavage planes, etc., inside. On deforming a ductile metal, slip takes place along these planes, but cell-wall accommodation is also necessary for change of shape without fracture. Thus, brittle cell walls due to the ejection of impurities or metallic compounds during solidification and cooling in the mould may even in very small quantity have a great effect on ductility.

Resistance to fatigue is different since breakdown may occur without any measurable plastic deformation. It has been proved, however, that at the region of stress concentration, the material should, for reliable service under most conditions, be capable of accommodation, accompanied by an increase in hardness without crack development. This tends to shift the locality of stress concentration to adjacent parts. At the same time its magnitude is automatically reduced owing to its distribution over a larger volume of material.

In the case of magnesium—a metal which crystallises according to the hexagonal system—

FIG. 1.—RAPIDLY-COOLED ALUMINIUM CONTAINING 1.4 PER CENT. FE AND 0.3 PER CENT. SI. × 5.

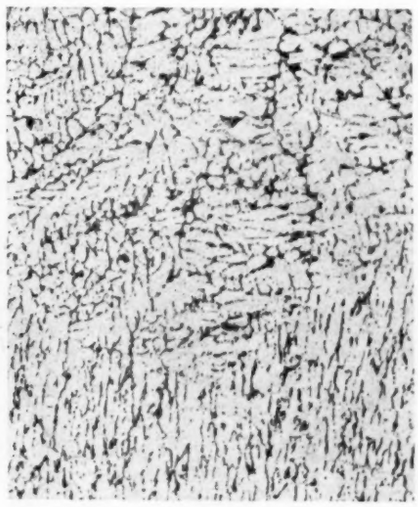


FIG. 2.—MACROSTRUCTURE OF AREA MARKED IN FIG. 1. × 100

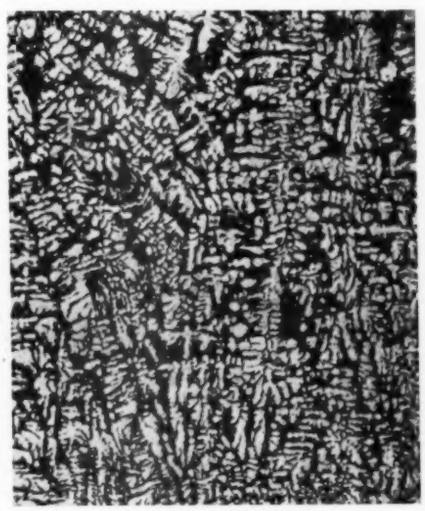


FIG. 3.—CRYSTAL STRUCTURE RESULTING FROM SLOW COOLING IN A SAND MOULD. × 10.

* Paper presented to the Thirty-Fourth Annual Conference of the Institute of British Foundrymen held in Derby from June 8 to 11, 1937.

very minute intercellular pores are much more common, owing apparently to the greater difficulty in packing or dovetailing hexagons at the boundaries of crystals. Such pores are particularly important when considering fatigue resistance. Aluminium alloy sand castings will contain cavities or pinholes if they are contaminated when in the liquid condition by the disengagement of hydrogen, carbides of hydrogen, and carbon monoxide, etc., during solidification. The development of these defects is facilitated by the considerable contraction that takes place simultaneously, *i.e.*, when the metal is changing from the liquid to the solid state. In chill castings the gases are generally trapped in solution owing to rapid cooling. There is no separation of slag as in steel, however, but there may be local intercrystalline weakness, due for instance to the separation of a copper-aluminium compound from its aluminium-rich matrix owing to the difference in coefficient of contraction. This may be one reason for the low strength of alloys compared with their calculated values from physical data.

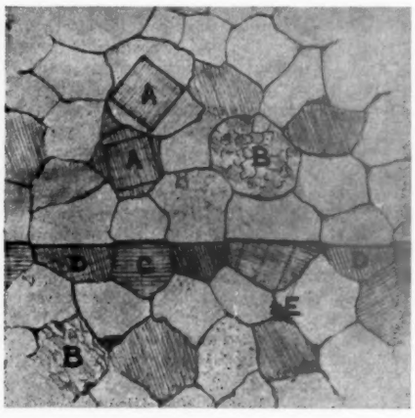


FIG. 4.—IDIOMORPHIC CRYSTALS OF IRREGULAR EXTERNAL, BUT REGULAR INTERNAL SYMMETRY. × 300.

Pinholes are often found, on microscopic examination, to be associated with copper segregation in spite of the solid separation of the latter taking place at a much lower temperature than that at which the pinholes form. Fig. 5 shows the pores in a 6 per cent. copper alloy, which suggest that some kind of association has existed even in the liquid state. Similarly an oil-water emulsion often has air bubbles trapped in it.

It should be observed that the mechanism of solidification has been considered by Desch, who investigated the supposition that the initial structure produced in an alloy was comparable with foam cells which appeared prior to normal crystallisation. The membranes, according to this theory, are similar to the "amorphous cement" of Rosenhain, both consisting of less pure metal than that inside the cells; this will be referred to again when considering "fluidity."

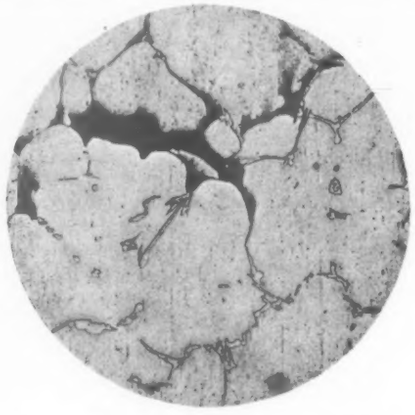


FIG. 5.—PORES IN A 6 PER CENT. COPPER ALLOY. × 150.

Modified Alloys

Common unavoidable impurities in aluminium are silicon and iron. The former if below 0.3 per cent. may be in a so-called solid solution in the aluminium, and is then invisible under the microscope. About 20 per cent. silicon can be dissolved in molten aluminium at about 800 deg. C. in spite of its own high melting point of 1,600 deg. C. On cooling to room temperature it is largely thrown out again. Fig. 6 shows the silicon-aluminium equilibrium diagram, wherein it is seen that the eutectic composition is 12 per cent. silicon, solidifying at 576 deg. C. The dotted lines show the undercooling effect of modification by traces of sodium. Rapid cooling produces a similar effect to a sodium addition, as it increases both tensile strength and the ductility. The curves on the lower part give an approximate idea of the change in ultimate strength and ductility with increase in silicon. This is a modified alloy cast in sand.

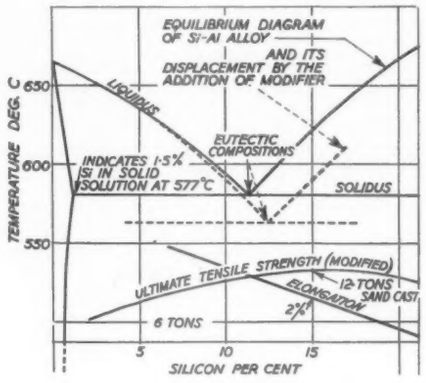


FIG. 6.—SI-AL EQUILIBRIUM DIAGRAM, AND THE EFFECT OF SI ON THE PHYSICAL PROPERTIES OF A SAND-CAST MODIFIED ALLOY.

Fig. 7 shows the structure of an unmodified alloy containing 12.7 per cent. silicon, in which the silicon in excess of that necessary for forming the eutectic is in massive particles. Fig. 8 shows the same alloy modified by 0.6 per cent. cobalt; an amount of 0.1 per cent. lithium and strontium would have a similar effect.

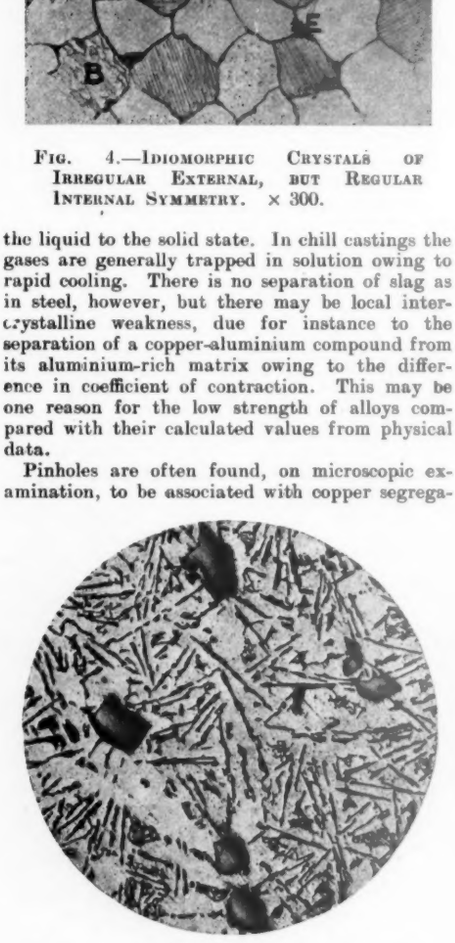


FIG. 7.—UNMODIFIED ALUMINIUM-SILICON ALLOY CONTAINING MASSIVE PARTICLES OF SILICON. × 100.

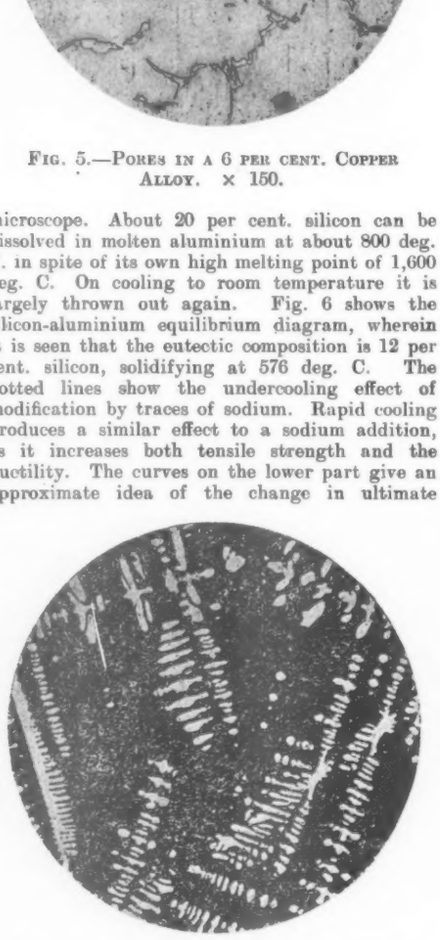


FIG. 8.—ALUMINIUM-SILICON ALLOY, CONTAINING 12.7 PER CENT. SILICON, MODIFIED BY 0.6 PER CENT. COBALT. × 100.

Aluminium Copper Alloys

Modification appears to alter the solubility of silicon in aluminium, tending to retard their separation on cooling. The fact that casting from a very high temperature, say 950 deg. C., into a chill mould produces a finer grain structure than casting from about 700 deg. C. in the same mould, suggests that separation or grouping of the silicon and aluminium takes place above the apparent solidifying temperature. This is confirmed by soaking a molten eutectic alloy at about 600 deg. C. in the crucible without stirring, when it is found that the lighter constituent, silicon, tends to rise. For similar reasons a copper-aluminium alloy with about 12 per cent. copper, treated in the same way, may have twice as much copper at the bottom of the pot after standing. Zinc behaves in a similar manner in spite of its greater solubility in aluminium. This is one reason for preferring alloys with relatively small percentages of heavy constituents, particularly for large melts or if the alloy be required to remain molten in the furnace for a considerable period.

It may be noted in this connection that induction-electric melting tends to maintain uniformity of composition by the stirring effect which tends to set up eddy currents. This may, however, increase oxidation if the alloy is inadequately protected by surface flux.

Copper was probably the most important constituent of aluminium alloys used in the past, and with more than 3 per cent. of copper, whether chill or sand cast, there is a cellular structure such as shown in Fig. 9, which is a 6 per cent. sand-cast aluminium alloy.

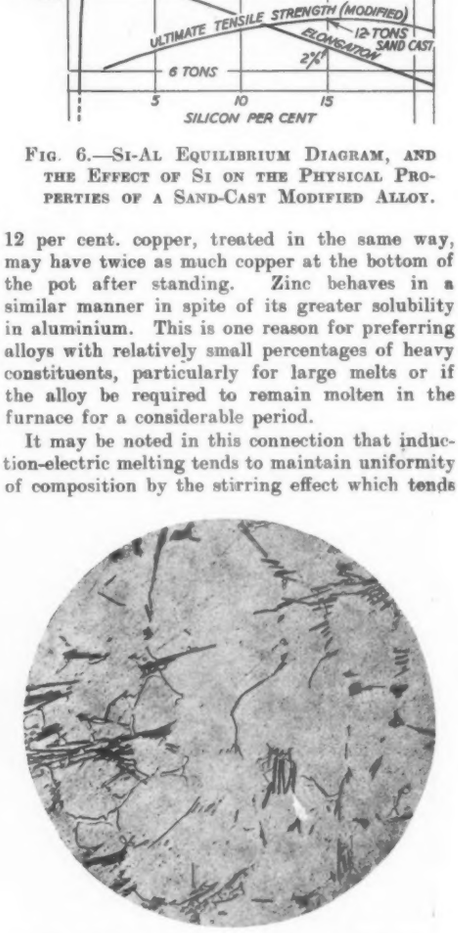


FIG. 9.—CELLULAR STRUCTURE OF 6 PER CENT. SAND-CAST COPPER ALUMINIUM ALLOY. × 150.

The network is the copper-aluminium compound $CuAl_2$—a very brittle constituent—and it is understandable that ductility is much decreased by its presence in the form shown. With the common 8 per cent. copper alloy, sand-cast, there is about 12 per cent. of compound by volume, and this reduces the ductility on the tensile test from about 25 per cent. elongation in the case of commercial aluminium to 2 per cent. This is

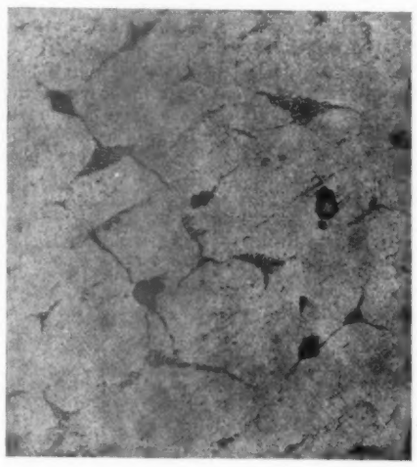


FIG. 10.—ALUMINIUM CONTAINING MAGNESIUM SILICIDE. × 300.

further reduced by low temperature heat-treatment at, say, 150 deg.

Efforts to eliminate the cellular formation of copper-aluminium eutectic, particularly in sand castings with about 8 per cent. copper, and thus to increase the ductility, have not been very successful, though 1.0 per cent. iron and about 0.25 per cent. titanium are beneficial. Beryllium and lithium also have a similar influence.

Another very important constituent of aluminium alloys is the compound magnesium silicide, Mg_2Si. Since silicon is always present in commercial aluminium and has a strong affinity for magnesium, it follows that Mg_2Si

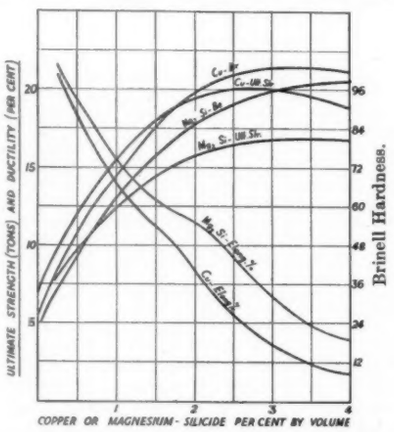


FIG. 11.—VARIATIONS OF ULTIMATE TENSILE STRENGTH, DUCTILITY AND BRINELL HARDNESS, WITH AN INCREASE IN COPPER AND MAGNESIUM SILICIDE (CHILL CAST AND HEAT-TREATED).

is always present when magnesium is added to aluminium. In this case (Fig. 10) distinct cellular formation is not produced. Nevertheless Mg_2Si has a great effect on the physical properties. Copper aluminide and magnesium silicide are the two most important constituents of aluminium alloys from the heat-treatment point of view, and both go into solid solution in aluminium containing them, if heated at about 500 deg. C. for a suitable period, *i.e.*, about half an hour for chill-cast alloy and at least three hours for a sand-cast alloy. Fig. 5 shows the 6 per cent. copper alloy treated in this way. Silicon also has a similar, though less marked, hardening effect, even without magnesium.

Table I shows the relative solubility of various constituents of aluminium alloys at ordinary temperature and at about 500 deg. C. The considerable difference in solubility at the two temperatures when alloys are capable of considerable response to heat-treatment is noteworthy.

TABLE I.—*Solid-solubility of Various Elements in Aluminium.*

Constituent.	Temperatures.	
	10 to 30 deg. C. Per cent. by weight.	490 to 510 deg. C. Per cent. by weight.
Copper	0.25	4.1
Magnesium	1.30	12.0
Silicon	0.20	1.1
Magnesium silicide ..	0.45	1.4
Manganese	0.20	1.0
Lithium	2.40	2.8
Silver	1.5	40.0
Cadmium	0.05	0.8
Zinc	3.2	42.0

Quenching from the solution temperature traps a large proportion of the $CuAl_2$ and Mg_2Si or Si in the solid-solution state. If more than one is present mutual effect on individual solubility in the aluminium is observed, as would be expected. Other constituents also complicate the behaviour of aluminium alloys, so that phase and equilibrium investigation may be very difficult when, for instance, iron about 1.0 per cent. is present. The compound $MgZn_2$ behaves similarly to Mg_2Si, although its solution temperature is lower, *i.e.*, about 450 deg. C., and its optimum ageing temperature about 100 deg. C.

Hardness and Strength Development

Solution treatment is, of course, carried out in order to develop maximum hardness and strength, but, as is well known, this result is not fully achieved without subsequent ageing or precipitation treatment. This latter may be practically complete by storage at normal air temperature for a week or so. Cast alloys, however, as a rule, require artificial heat, *i.e.*, heating to about 150 deg. C. for 12 hrs., the hardness thereby increasing from about 75 in the solution-treated condition to as much as 150 Brinell. The changes in mechanical properties may be considered to be largely due to the intimate association of one volume unit of the constituent Cu or Mg_2Si (by atomic dispersion in the aluminium space lattice during solution treatment) with about 50 units of aluminium. The resultant group, *i.e.*, 51 in volume plus a slight increase due to the new arrangement or packing, has special properties. For instance, on precipitation treatment the Cu or Mg_2Si, which is present as a distorting factor in each group, tends to cause internal stress by diffusion and segregation, which upsets the normal easy slip along crystal planes, acting apparently as if to increase the internal friction. Thus, under externally loading plastic, deformation is less, *i.e.*, the material is harder.

From tests it can be shown that with about 2.0 per cent. Cu or Mg_2Si by volume there is, as previously suggested, a maximum effect due to heat-treatment when about 50 volumes of aluminium are associated with one unit of these compounds. If more compound than this proportion is present, hardness is not increased in proportion, but ductility decreases markedly owing to the excess $CuAl_2$ or Mg_2Si being deposited at cell walls, these taking little part in the changes during solution and ageing treatments.

Fig. 11 shows at volume percentages the hardness and ductility variation and maxima obtained by complete heat-treatment with an increase in copper and magnesium silicide.

(To be concluded.)

The Hardening Power of Cast Iron

In a Paper which Mr. D. W. Murphy and Mr. W. P. Wood presented to the annual conference of the American Foundrymen's Association, held in Milwaukee recently, it was shown that consistent differences in the hardening power of cast irons arose from variations in deoxidation practice, and that melting practice had a considerable influence on the effect of a given amount of deoxidiser on the behaviour of the metal. These changes in melting and deoxidation practice were apparently more readily followed by hardening power tests than by most of the physical properties. It was also indicated that a study of the properties of heat-treated irons of varying hardening power characteristics may prove enlightening to present conceptions of the influence of various factors on physical properties.

Wide differences in the hardening power of irons of similar composition and graphite dispersion existed which could not be explained by ordinary chemical analyses or by differences in graphite distribution. These differences in hardening power were related directly to the deoxidation and to the melting practice.

Aluminium additions of the order of 0.02 to 0.03 per cent. produced shallow hardening characteristics in the base irons studied; larger additions of aluminium, however, failed to produce shallow hardening characteristics, although they did produce a slightly lower intensity of hardness in the heat-treated condition.

The resolution of the austenitic grain size was not as successful as was desired, but it seemed as though the truly shallow hardening irons showed a fine austenitic or inherent grain size in comparison with the deep hardening irons.

There was an indication from the microscopic studies that the fineness of the pearlite in the iron would vary with the hardening power, the shallow hardening irons showing the finest pearlite. It was suggested that the variation in fineness of pearlite was due to variations in the rate of the austenite to pearlite transformation, the shallow hardening irons possessing the higher rates of transformation.

The as-cast transverse properties obtained from 1.2-in. bars were relatively insensitive to changes in hardening power, although it was indicated that shallow hardening irons showed greater rates of deflection than did deep hardening irons. The tensile strength of as-cast bars decreased in the shallow hardening irons. This property might show greater variation in smaller sections.

Brinell hardness tests on sections from 1.2-in. bars as-cast are relatively insensitive to changes in hardening power. Shallow hardening irons seemed to show a considerably higher as-cast impact strength than did deep hardening irons. The as-cast physical properties of the 1.2-in. bars did not reflect well the changes in hardening power brought about by variations in melting and deoxidation practice. It is suggested that heat-treated specimens, as well as those of small section as-cast, might be more responsive to these changes.

Low-Carbon Cast Iron

An article by N. G. Girshovitch and V. A. Mikhailov, in "Litenoye Dyelo," gives the results obtained in the Lepsye malleable iron foundry which for the past eighteen months has been producing low carbon cast iron regularly by the Girshovitch method, in which the hearth of the cupola is raised to the level of the tuyeres. The results of a number of tests show that 92.5 per cent. of all the test-pieces had a tensile strength of greater than 22 tons per sq. in., while 87 per cent. of the test-pieces had a tensile strength greater than about 25½ tons per sq. in. In the case of 90 to 94.2 per cent. of the test-pieces, the elongation exceeded 6 per cent., and in no case was the elongation less than 5 per cent.

Alloying Cupola Grey Cast Iron*

By F. E. FISHER

In many types of castings the use of alloys to improve the quality of cast iron is ever becoming more desirable and more necessary. There are many alloys to which the foundryman may turn, and much progress is being made in perfecting suitable base mixtures in which to introduce those alloys.

The base iron must first be considered in order to derive the greatest good from the correct amount of alloy. When a foundry superintendent wishes to improve the quality of his product, he does not immediately purchase the more expensive alloys, expecting them to overcome troubles caused by lack of attention to some fundamental principle of good foundry practice, but he checks closely the quality of his raw materials both as to physical properties and chemical composition. He examines the operation and control of his cupola with particular attention to the weights and arrangement and size of the materials in each charge. Once he is convinced that these variables are correctly standardised and that his base iron is correct, he then knows that further improvement may be gained by the judicious and practical use of alloying elements in castings used for specific purposes.

The general run of base irons as they come from the cupola may range from 20 to 80 per cent. scrap in mixture, some containing as much as 70 per cent. steel, some with 10 per cent. pig-iron and some with 60 per cent. pig-iron. The various percentage combinations of scrap, returns, steel and pig-iron used are numberless. Yet each combination is made up with a definite casting analysis in view.

The casting analyses are as varied in number and chemical composition as the base mixtures. Each foundryman may differ in his idea of what constitutes the ideal base iron and the ideal chemical analysis he hopes to get.

The casting analyses guide, shown in Table I, lists a variety of castings and also indicates an approximate analysis which may be used as a guide in making up the base mixture for the particular variety of casting in question. It will be noted that the analyses guide mentions only the silicon, sulphur, phosphorus, manganese and total carbon. In many cases the silicon and phosphorus ranges are wide, but the author believes the limits shown cover the field and, as a whole, will average fairly close to the present trend.

The more commonly used alloys are listed in the following paragraphs, and their effects on the physical properties of the cast iron are discussed briefly.

In most instances the alloys shown here may be added either in the spout or ladle and in some instances to the cupola charge. The method used in adding the alloys depends to some extent on the amount of iron to be alloyed, the size and alloy content of the alloying material and the amount required to obtain the desired results. Alloys are generally added to the charge when the melt is large or in production, and to the spout or ladle when the amount of iron to be treated is small. Many foundries run a continuous melt of six to eight hours and use one base mix throughout the entire day, alloying occasional ladles as needed on the pouring floors.

As the physical properties differ greatly in the alloys, care should be exercised in the selection, type, size and amount added to the metal. Much expensive alloy is used to-day in castings which really do not require any, while, on the other hand, many castings would be greatly improved with intelligent use of one or more of the alloys.

* From the "Iron Age." The author is foundry adviser, Chicago Office, Sloss-Sheffield Steel & Iron Company.

Chromium

Ferro-chromium may be added in either cupola, spout or ladle. This material contains 65 to 70 per cent. chromium and has a melting point of about 1,260 deg. C. When used in the spout or ladle, 20 to 30 mesh size is most practical and recovery averages close to 90 per cent. When added in the cupola, lump ferro is generally used.

Chromium is sometimes introduced into the cupola charges in the form of briquettes which contain two pounds of alloy, and in other cases briquettes are used, it is recommended that they be placed on the coke in the centre of the cupola.

Chromium is added alone or in combination with other alloys, mainly nickel, molybdenum or copper. Chromium is a hardener, and, as such has the tendency to increase chill and strength and is freely used in castings which are chilled or which require a white fracture with extreme hardness. Chromium increases the resistance to wear, heat, corrosion and growth. It refines the grain, retards the formation of graphite, and increases combined carbon.

In the 1935 edition of the Cast Metals Handbook, it is pointed out that in heavy sections, the use of chromium helps to give a more uniform hardness with change of section. Chromium additions reduce the graphitic carbon content and decrease the flake size. Chromium favours the formation of more finely laminated and harder pearlite. In a suitable base iron, these effects add to tensile strength, promote finer grain size, and increase hardness. The in-

TABLE I.—*Casting Analyses Guide.*

Approximate analyses of grey-iron castings. These ranges are not specifications, but are sufficiently accurate to produce sound castings with good foundry practice. The sulphur recommendations are somewhat high, but the figures shown are maxima, and, if proper balance of silicon, carbon, phosphorus and manganese is obtained, the maximum sulphurs should not be harmful. The lower carbons can be reached provided the base mixture is of proper materials and the cupola practice is good.

Castings.	T.C.	Si.	Mn.	S, Max.	P.
Acid-resisting	2.80–3.10	0.90–2.00	0.70–1.10	0.06	0.40–0.50
Agricultural	3.30–3.60	2.00–2.50	0.55–0.75	0.09	0.80–1.00
Aluminium pots—goose necks	3.00–3.15	1.40–1.75	0.55–0.70	0.08	0.50–0.60
Annealing boxes	3.30–3.50	0.70–0.80	0.30–0.40	0.09	0.40–0.50
Bed plates	3.25–3.50	1.40–1.80	0.75–0.85	0.11	0.60–0.80
Boiler parts	3.25–3.40	2.00–2.50	0.70–0.80	0.08	0.50–0.60
Brick dies	2.90–3.15	0.40–0.80	0.50–0.70	0.15	0.60–0.80
Brake shoes	2.90–3.15	1.30–1.50	0.50–0.60	0.13	0.50–0.60
Brake drums	3.00–3.20	1.60–1.80	0.60–0.70	0.09	0.40–0.50
Car wheels, chilled mine	3.00–3.25	0.90–1.15	0.50–0.60	0.11	0.45–0.55
Caustic soda pots	2.80–3.10	0.80–1.10	0.60–0.80	0.07	0.40–0.50
Chills	2.80–3.10	0.80–1.10	0.60–0.80	0.07	0.40–0.50
Chilled crusher, head plates	2.90–3.20	0.70–0.90	0.70–0.90	0.09	0.40–0.50
Chilled rolls	3.00–3.25	0.65–0.85	0.50–0.70	0.08	0.40–0.50
Clutches	3.00–3.25	1.90–2.20	0.60–0.70	0.09	0.60–0.70
Cylinders, air	3.00–3.25	1.10–1.75	0.75–1.00	0.10	0.40–0.60
Cylinders, ammonia	3.00–3.25	1.10–1.75	0.75–1.00	0.10	0.40–0.60
Cylinders, automobile	3.10–3.25	2.15–2.30	0.60–0.80	0.09	0.30–0.35
Cylinders, gas engine	2.90–3.15	1.25–2.25	0.60–0.80	0.11	0.40–0.50
Cylinders, hydraulic	2.90–3.15	1.00–1.40	0.70–0.90	0.10	0.35–0.50
Cylinders, locomotive	2.90–3.20	1.10–1.40	0.70–0.90	0.10	0.35–0.50
Cylinders, motor cycle	3.25–3.50	2.50–2.90	0.60–0.80	0.09	0.50–0.60
Cylinders, steam and oil	3.00–3.25	1.40–1.80	0.60–0.80	0.10	0.40–0.50
Dies	3.00–3.25	1.00–1.50	0.60–0.80	0.09	0.30–0.40
Electrical	3.30–3.60	2.60–2.90	0.60–0.70	0.07	0.70–0.90
Fire pots	3.10–3.30	2.00–2.30	0.60–0.80	0.08	0.80–0.90
Fly wheels	3.10–3.30	1.25–1.75	0.60–0.80	0.08	0.40–0.50
Furnace parts	3.10–3.30	2.00–2.50	0.60–0.80	0.08	0.70–0.80
Gears	3.20–3.40	1.50–2.00	0.60–0.70	0.08	0.70–0.80
Glass moulds	3.30–3.50	1.75–2.25	0.70–0.80	0.08	0.25–0.35
Glass plungers	3.30–3.50	1.60–1.80	0.65–0.75	0.08	0.30–0.40
Grate bars	3.10–3.30	2.00–2.30	0.60–0.80	0.07	0.70–0.80
Grinding balls	3.25–3.50	0.75–1.25	0.40–0.60	0.12	0.40–0.50
Gun iron	2.90–3.10	1.15–1.35	0.70–0.90	0.08	0.40–0.50
Hardware	3.30–3.60	2.40–2.65	0.60–0.70	0.08	0.80–0.90
Heat resistant castings, light	3.00–3.25	2.00–2.40	0.60–0.70	0.08	0.70–0.80
Heat resistant castings, medium	3.00–3.25	1.50–2.00	0.50–0.60	0.08	0.70–0.80
High strength	2.75–3.00	1.50–1.80	0.75–0.90	0.10	0.40–0.50
Liners, heavy	3.00–3.20	0.85–0.95	0.75–0.85	0.12	0.50–0.60
Machinery castings, light	3.30–3.55	2.40–2.70	0.55–0.65	0.08	0.80–0.90
Machinery castings, medium	3.10–3.35	1.90–2.40	0.65–0.75	0.09	0.70–0.80
Machinery castings, heavy	2.90–3.15	1.40–1.90	0.75–0.85	0.10	0.60–0.70
Melting pots, lead	3.00–3.25	1.15–1.40	0.50–0.70	0.08	0.70–0.80
Mine wheels	3.00–3.20	1.10–1.30	0.55–0.65	0.10	0.70–0.80
Ornamental	3.35–3.60	2.40–2.75	0.60–0.70	0.08	0.80–1.00
Permanent moulds	3.20–3.40	1.75–2.15	0.60–0.80	0.07	0.70–0.80
Piano plates	3.25–3.50	2.10–2.30	0.60–0.70	0.08	0.70–0.80
Piston automobile	3.25–3.50	2.40–2.60	0.60–0.70	0.09	0.50–0.60
Piston rings, cupola	3.25–3.50	2.60–2.80	0.60–0.70	0.08	0.50–0.60
Plough points	3.30–3.40	0.80–1.10	0.70–0.80	0.09	0.60–0.70
Pulleys	3.30–3.50	2.00–2.40	0.60–0.70	0.09	0.60–0.80
Radiators	3.30–3.45	2.25–2.50	0.65–0.75	0.08	0.75–0.85
Rolls, sugar mills	3.35–3.60	2.50–2.75	2.00–2.50	0.08	1.00–1.25
Rolls, briquette	3.10–3.25	1.40–1.75	0.60–0.75	0.10	0.60–0.75
Rolls, dryer paper	3.15–3.35	2.00–2.20	0.70–0.80	0.10	0.60–0.75
Sand pumps	3.15–3.30	1.25–1.75	0.50–0.60	0.11	0.60–0.70
Steam fittings	3.15–3.30	1.70–2.10	0.60–0.75	0.09	0.55–0.65
Stove plate	3.40–3.60	2.35–2.55	0.50–0.65	0.08	0.70–0.90
Valves, small and medium	3.30–3.50	1.75–2.10	0.50–0.60	0.09	0.70–0.80
Valves, large	3.20–3.40	1.40–1.75	0.60–0.70	0.10	0.60–0.70
White iron castings	2.75–3.10	0.40–0.80	0.50–0.70	0.20	0.60–0.80

fluence of chromium on the structure of soft cast iron is shown in Table II.

TABLE II.—*Approximate Effect of Chromium on a Soft Cast Iron.*

Chromium. Per cent.	Structure.
0.0	Ferrite and coarse graphite.
0.30	Less ferrite and finer graphite and pearlite.
0.60	Fine graphite and pearlite.
1.0	Fine graphite and pearlite and small carbides.
3.0	Graphite disappears.
5.0	Much massive carbide.
10 to 30	Fine carbides.

Copper

Copper is generally added to the ladle in its purest form as scrap or shot. Some foundries use copper pigs and make the additions in the cupola. The melting point is approximately 1,065 deg. C. Copper tends to refine the grain structure and decreases chill in light sections. The tensile strength is increased slightly with little or no effect on transverse strength. Up to 0.50 per cent. copper acts as a graphitiser and decreases chill, but from 0.50 up to 1.50 per cent. hardness is increased. The formation of silicides with increased hardness is quite noticeable at 0.75 per cent. Copper is used with chromium, nickel or molybdenum or combinations of the alloys. Ni-Resist contains 6 per cent. copper, 14 per cent. nickel, and 2 per cent. chromium. It is highly resistant to corrosion and growth at higher temperatures, and is well adapted for castings used in chemical and oil refining equipment.

Manganese

Manganese is added to cast iron in many forms. It may be added in the cupola charges, spout or ladle and the method of addition is governed by the type of material used.

Cupola additions are made by using pig-iron, lump ferro-manganese, spiegeleisen or manganese briquettes. Spiegeleisen contains approximately 20 per cent. manganese, lump ferro-manganese contains 70 to 80 per cent. manganese, and the briquettes contain two pounds of manganese and one-half pound of silicon per briquette.

For ladle and spout additions, the normal ferro-manganese crushed to 20 mesh and under is generally used. The melting point of ferro-manganese is 1,232 to 1,315 deg. C., and recovery averages 80 to 85 per cent. Manganese promotes fluidity and soundness, increases tensile and transverse strength, is an excellent deoxidiser, softens cast iron up to 0.75 per cent. and beyond that point, has little effect on hardness until 1.25 per cent. is reached, when it increases the hardness. Manganese is liberally used when sulphur is high.

Molybdenum

Additions of ferro-molybdenum to cupola cast iron are generally made in the ladle using material crushed to 20 mesh or less. Lump ferro-molybdenum may be charged in the cupola, but this method is not considered best practice.

Ferro-molybdenum contains 60 to 70 per cent. molybdenum and melts at a temperature of about 1,510 deg. C., but is quite soluble in cast iron. A recovery of 90 per cent. may be expected.

Molybdenum is a carbide-forming alloy as well as a deoxidiser. It increases the tensile, transverse and compressive strengths, refines the graphite and promotes a close grain with a "satin" fracture. The Brinell hardness is increased with slightly decreased machinability. Molybdenum increases resistance to wear and heat, reduces shrinkage and porosity, and castings in which it is included may be heat-treated easily. Molybdenum is often used with nickel or chromium or both.

Nickel

Nickel is added to cast iron as pure nickel, "F" nickel shot, or as nickel pig. For ladle and spout additions the nickel shot (which melts at 1,260 deg. C.) is used. This material contains 92 per cent. nickel and 6 per cent. silicon. The pure nickel melts at 1,448 deg. C. and contains 99.65 per cent. nickel.

Nickel pigs weighing 5 lbs. are ordinarily used in producing Ni-Resist castings. The pigs are added to the cupola and contain 58 per cent. Ni, 24½ per cent. copper and 8 per cent. chromium, with smaller amounts of silicon, carbon and manganese, melting at 1,260 deg. C. It is recommended that 27½ per cent. of this nickel pig be used in making Ni-Resist cast iron which contains approximately 14 per cent. Ni, 6 per cent. copper and 2 per cent. chromium. Nickel recovery in the cupola or ladle is usually over 95 per cent.

Several grades of nickel- and chromium-bearing pig are extensively used to introduce Ni into the mixture. One grade contains approximately 1.10 per cent. Ni, 2.20 chromium and ordinary silicon. Another grade is produced with nickel over 1 per cent., chromium over 2 per cent., silicon 9 to 12 per cent., with 2.50 per cent. carbon. This pig is, of course, charged into the cupola in the usual manner.

Nickel has a graphitising effect, reducing the tendency to chill and increase machinability when used in small percentages, but tends towards hardness if over 5 per cent. Nickel promotes freedom from porosity and uniformity of grain. Silicon is usually lowered when nickel is used. Various combinations of nickel, chromium and molybdenum are quite universally in use to produce improvements in strength, wear, abrasion, corrosion, and heat resistance and density and impact values.

Silicon

The properties imparted to cast iron by silicon additions are well known, and no effort is made here to elaborate on the subject. Silicon is added to cast iron in the cupola, spout or ladle. It is added in many forms such as 50 to 80 per cent. ferro-silicon, pig-iron, briquettes and silico-spiegel. For cupola additions silicon briquettes containing 1 or 2 lbs. of silicon per briquette may be used. High silicon pig-iron, or ferro-silicon are quite generally used, also.

TABLE III.—*Approximate Weight of Alloy Required for each 100 lbs. of Metal.*

Alloy, per cent. desired in casting.	Ferro-Cr, 70 per cent.		Cu, 99 per cent.		Ferro-Mo, 65 per cent.		Ferro-Mn, 80 per cent.		Ferro-Si, 50 per cent.		Ni "F," 92 per cent.	
	lbs.	ozs.	lbs.	ozs.	lbs.	ozs.	lbs.	ozs.	lbs.	ozs.	lbs.	ozs.
0.20	—	5	—	3	—	5	—	6	—	8	—	3
0.30	—	7	—	5	—	8	—	7	—	10	—	5
0.40	—	9	—	6½	—	11	—	9	—	13	—	7
0.50	—	11	—	8	—	14	—	12	1	—	—	9
0.60	—	14	—	10	1	—	—	15	1	3	—	11
0.70	1	1	—	12	1	3	1	1	1	7	—	13
0.80	1	3	—	14	1	6	1	2	1	11	—	15
1.00	1	8	1	—	1	10	1	3	2	—	1	1
1.25	1	13	1	4	2	—	1	5	2	8	1	5
1.50	2	2	1	8	—	—	1	14	3	—	1	10
1.75	2	8	1	12	—	—	2	6	3	8	1	15
2.00	2	14	2	—	—	—	2	12	4	—	2	3
2.25	3	4	2	4	—	—	3	2	4	8	2	7
2.50	3	9	—	—	—	—	3	8	5	—	2	11
2.75	3	14	—	—	—	—	4	—	5	8	3	—

Ladle additions should be made with either 50 or 80 per cent. ferro-silicon crushed to ⅛ in. This material melts at approximately 1,343 deg. C., and silicon recovery is about 85 per cent.

Silicon is a softener and graphitiser, and decreases tensile and transverse strengths and chill depending upon the total carbon content.

In discussing silicon, the Cast Metals Handbook says: "A comparatively few years ago the influences of total carbon on cast iron were not well understood by most foundrymen, and carbon control methods were neglected. Silicon was the controlling factor to many foundry mixture makers. To-day, through increased knowledge of the effects of carbon content and other factors, silicon contents, while carefully regulated, may vary greatly from those formerly specified. For example, most modern high-duty irons are low in total carbon, and in these irons much higher silicon contents are permissible, in fact are needed, than is proper for higher carbon irons."

Titanium

Ferro-titanium additions are generally made in the ladle using 20 mesh material. This alloy contains approximately 16 per cent. titanium, with 50 per cent. recovery. It is considered a deoxidiser and graphitiser and reduces chill and graphite flake size. Strength is not increased when titanium alone is added, but some operators have obtained much higher strengths with increased hardness when combining it with chromium—the chromium counteracting the graphitising effect of the titanium and promoting more sorbitic structures.

Vanadium

Ferro-vanadium is added to the ladle. It contains 35 to 40 per cent. vanadium and melts at 1,260 to 1,398 deg. C. The recovery is estimated to be 85 per cent. and 20 mesh size is used. Vanadium is a deoxidiser and degasifier, increases strength and hardness, refines grain and toughens the irons. It is a carbide-forming element, increasing the combined carbon content.

Zirconium

Zirconium may be added to cast iron in the ladle in the form of silicon-zirconium which contains 40 per cent. zirconium and 50 per cent. silicon. Its recovery is very low, as most of the alloy is used up in its strong deoxidising and degasifying effect. Zirconium promotes a fine grain structure, increases fluidity and strength and deflection and has a strong graphitising influence with little decrease in hardness. Tensile strengths of 22 tons per sq. in. have been obtained with 0.30 to 0.50 per cent. zirconium, provided the silicon and manganese contents are properly balanced.

Phosphorus

Phosphorus in the form of the ferro-alloy, which contains from 18 to 22 per cent. phosphorus, is added to the base iron when it is too low in phosphorus. It, like other ferro-alloys, is added in lump form in the cupola or in granular form in ladle additions. Among other properties phosphorus adds fluidity without raising the casting temperature to an iron extremely low in total carbon and increases resistance to wear.

Other alloys, such as cobalt, boron, calcium, aluminium, tungsten and cerium, are being used with varying success, but are not yet universally accepted.

(*Concluded on page* 529.)

The Use of Nickel in Non-Ferrous Alloy Castings

By J. O. HITCHCOCK, B.Sc.

(*Concluded from page* 516.)

Cadmium-Base Alloys

A further group of bearing alloys which has been studied and developed in recent years is that having cadmium as a base. Silver and copper have both been used as hardeners in cadmium, but most commercial development has taken place with an alloy containing nickel as the essential hardening element called "Asarcoloy" in America and cadmium-nickel N.S.5 bearing metal in this country. This alloy contains 1.3 per cent of nickel. Nickel combines with cadmium (to a formula approximating to $NiCd_4$) to give a hard metallic compound which itself is embedded in a eutectic of this compound and cadmium, resulting in a typical so-called bearing structure. The requirements in a bearing metal for high-duty service are well satisfied by an alloy of this nature, especially from the point of view of retention of hardness and strength at elevated temperatures, a matter of growing importance in modern internal combustion engines. The following figures illustrate this point:—

Temperature. Deg. C.	Tensile strength. Tons per sq. in.	Brinell hardness number.
28	7.2	32.5
100	6.8	17.5
150	—	12.0
200	1.47	7.5

As in the case of the nickel-containing lead-base alloys, care is necessary in the metalling operations. Melting points and pouring temperatures are, of course, higher than the tin-base alloys, and slow cooling is essential to prevent cracking. High bond-strengths are, however, readily obtainable. Cadmium-nickel bearing alloys have been adopted as standard for big-end motor-vehicle engine bearings, etc., and probably they would have become further established were it not for the uncertainty which has existed concerning world cadmium supplies and prices.

Aluminium Alloys

A further group of alloys to be considered in connection with small nickel additions is the important field of light aluminium alloy castings. The general effects of nickel, when correctly applied, are, both before and after the usual type of age-hardening treatment, an all round improvement in physical and mechanical properties, particularly from the point of view of strength at elevated temperatures. It would not be possible in the space available to deal with each nickel-containing aluminium casting alloy individually, but Tables II and III set forth the composition and properties of those commonly employed in this country. Table IV gives the heat-treatments required to develop the maximum mechanical properties and Table V shows the physical properties of the same alloys, some of which are covered by patents.

The heat-treatment of the nickel-containing alloys is of the same nature as that for Duralumin, namely, a softening quench followed by a hardening (precipitation-hardening) ageing treatment at room or slightly elevated temperatures. The constituents causing hardness are not, however, identical with those in Duralumin. Nickel modifies the normal $CuAl_2$ compound and also combines with aluminium as $NiAl_3$.

"Y" alloy, the best-known alloy in this group, was first developed during the war to meet the need for a strong light alloy suitable for aero-engine pistons. Its properties at high temperatures are particularly good, and it is free from hot-shortness. Gravity die-cast "Y" alloy pistons are extensively used in the motor industry, but to some extent castings are being replaced by forgings in aero engines. Light marine diesel-engine pistons are cast in "Y" alloy and improved results, from the point of view of overcoming distortion troubles in these castings have been obtained by increasing the ageing temperature over that shown in Table IV.

The "R.R." group of alloys are a further development in the field of high-strength aluminium casting alloys. R.R.53C combines the excellent casting properties which R.R.50 possesses with the high tensile strength of R.R.53, in such a way as to permit intricate parts to be cast and heat-treated without fear of excessive casting and heat-treatment stresses. At temperatures above 200 deg. C., however, it is inferior to R.R.53 The applications of the R.R. casting alloys are similar to those of "Y" alloy and include such parts as crankcases, cylinder heads, etc.

TABLE II.—*Chemical Compositions of Nickel containing Aluminium Casting Alloys.*

Alloy.	Cu.	Ni.	Mg.	Fe.	Si.	Mn.	Ti.
"Y"	4.0	2.0	1.5	0.6*	0.6*	—	—
R.R.50	1.3	0.9	0.1	1.2	2.25	—	0.18
R.R.53	2.2	1.3	1.5	1.2	1.25	—	0.07
R.R.53C	1.15	0.8	0.5	1.1	2.5	—	0.16
Ceralumin "C" ..	2.5	1.5	0.8	1.2	1.2	—	Ce 0.15
"Lo-Ex"	0.9	2.0	1.0	—	14.0	—	—
"Birmasil Special" ..	0.1*	2.5–3.5	—	0.6*	10.0–13.0	0.5*	—
"P.2"	3.0–4.5	1.75–2.5	0.5*	2.0–4.0	4.0–5.0	0.5*	—

* Maximum.

In the "Ceralumin" alloys use is made of cerium to improve the running property of the alloys and generally to refine the macrostructure. The properties and applications of these alloys are not substantially different from those previously mentioned. "Lo-Ex" is interesting in that, whilst its mechanical properties are slightly lower than the other high-strength aluminium casting alloys, the high silicon lowers the coefficient of expansion to an extent sufficient to reduce considerably the design troubles associated with the high expansion of the ordinary aluminium alloys. The nickel gives increased hardness and improved properties at elevated temperatures. The presence of 3½ per cent. nickel in the "Birmasil Special" alloy enables an alloy to be produced possessing the good founding properties and resistance to corrosion of the high silicon alloys without the disadvantage of the low yield point normally associated with this type of alloy. "P.2" has been specially developed for small pressure die-castings required with close tolerances.

The above remarks by no means include all the various alloys of aluminium containing nickel used in other parts of the world, nor do they more than suggest the applications of this type of alloy.

In preparing nickel-aluminium alloys, the nickel is most frequently added to the molten aluminium in the form of a nickel-aluminium or nickel-aluminium-copper "hardener" containing 20 per cent. nickel, but the presence of nickel entails no special treatment in the production of castings.

Copper

Little attention has been given in the past to castings in copper containing a relatively small percentage of nickel, *e.g.*, below 10 per cent. For one application, however, castings in such alloys are of considerable industrial importance. These are the slip-rings used in various electrical machines. Slip-rings collect and deliver current to rotating members and have constantly been a source of trouble, due to the occurrence of uneven wear. Cast cupro-nickel rings containing

TABLE III.—*Mechanical Properties of Nickel-Containing Cast Aluminium Alloys.*

Alloy.	Form.	Tensile. Heat-treatment.	Proof stress 0.1 per cent. Tons per sq. in.	Y.P. Tons per sq. in.	M.S. Tons per sq. in.	E. Per cent.	B.H.N.	Fatigue limit. Tons per sq. in.
"Y"	Sand cast	Quenched and aged	—	—	14–16	1–3	95–105	—
"	Chill cast	Quenched and aged	—	—	18–20	3–5	100–110	± 7·1*
R.R.50 ..	Sand cast	Precipitation only	9–11	—	11–13	2–4	65–75	± 4.5†
"	Die cast	Precipitation only	11–13	—	13–16	4–6	70–80	± 5.8†
R.R.53 ..	Sand cast	Complete	—	—	18–20	0.5–1.0	124–148	± 5.5†
"	Die cast	"	19–22	—	21–23	0.5–1.5	124–148	± 6.9†
R.R.53C ..	Sand cast	"Solution" only	9–10	—	14–15	2.5–3.0	70–75	—
" ..	"	Complete	18–20	—	19–22	1–2	100–115	—
" ..	Die cast	"Solution" only	10–12	—	18–20	6–8	75–85	—
" ..	"	Complete	19–21	—	22–24	3–6	110–120	—
Ceralumin "C"	Sand cast	"Solution"	11–13	—	14–16	1–3	98–104	—
" "	"	Complete	18–20	—	19–20	0–1	130–140	—
" "	Chill cast	"Solution"	13–14	—	19–21	4–6	98–104	—
" "	"	Complete	21–24	—	23–27	0–1	130–140	± 8.25*
"Birmasil Special"	Sand cast	—	—	7–9	12–14	2–4	50–70	± 3.5*
"	Chill cast	—	—	8.5–10.5	16–18	3–6	70–89	± 5.3*
"Lo-Ex" ..	"	—	—	9.5–11.5	10–13	0–0.5	65–75	—
" ..	"	Complete	—	15.2–16.4	16–19	0–0.5	125–140	—
"P.2"	Pressure die cast	—	—	7.0–11.5	9.5–12.25	0.5–2.0	65–101	± 4.25*

* 20,000,000 reversals. † 40,000,000 reversals.

4 to 6 per cent. of nickel have been found to overcome this trouble and are in wide use. The nickel hardens the copper, increases its corrosion resistance and enables it to be more easily cast. Sand castings are rather more easily produced than chill castings; oxidising conditions in the furnace followed by a manganese deoxidation treatment are desirable. Higher nickel/nickel-copper alloys are, of course, in extensive use, but it is not proposed to deal with these in any detail here.

TABLE IV.—*Heat-Treatment of Cast Aluminium Alloys.*

Alloy.	Solution treatment.			Ageing treatment.		
	Heat at deg. C.	Hrs.	Quench in.	Heat at deg. C.	Hrs.	Quench in.
"Y"	510–520	2	Boiling water	100	2–3	Water or air
"Y"	510–520	2	" "	Room temperature	120	
R.R.50	—	—	—	170	10–20	" "
R.R.53	525–535	2–4	Boiling water	170	15–20	" "
R.R.53C	525–535	2–6	" "	165	15–20	" "
Ceralumin "C" ..	515–535	4–6	Water	175	16	Water
"Lo-Ex" ..	515	2–3	"	180	2	—

Nickel-Base Alloys

The foregoing sections have dealt with the question of the effect of nickel additions on commonly used non-ferrous casting alloys—the main purpose of the Paper, but in addition to the materials falling into these classes there are, of course, numerous casting alloys which have nickel as their base and which should be briefly mentioned. For reference purposes a summary of the various types is given below:—

Nickel.—Pure nickel itself is used in the form of castings required for chemical plant. It has a melting point of approximately 1,450 deg. C., and therefore requires efficient melting equipment. Special attention must be paid to the presence of impurities and to moulding. The following are the approximate mechanical properties of nickel castings:—

Yield point. Tons per sq. in.	Maximum stress. Tons per sq. in.	Elongation. Per cent. on 2 in.
9 to 13	27 to 31	15 to 35

Monel.—The nickel-copper alloy "Monel" (nickel 67, copper 28 per cent., iron, silicon, manganese balance) is widely used in the cast form for valve parts, chemical castings, etc. As in the case of nickel, close attention to foundry details is essential. As-cast Monel has the following typical properties:—

Yield point. Tons per sq. in.	Maximum stress. Tons per sq. in.	Elongation. Per cent. on $4\sqrt{\text{area}}$.	B.H.N.
14	24	18	120

By increasing the silicon content of Monel castings, the hardness is greatly increased and silicon Monels are specially useful for steam valve parts. They are susceptible to further hardening by a heat-treatment of the precipitation-hardening type.

	Yield point. Tons per sq. in.	Maximum stress. Tons per sq. in.	Elongation. Per cent. on 2 in.	B.H.N.
Monel with 2.75 per cent. silicon	23	38	16	210
Monel with 3.75 per cent. silicon	40	45	5	270

Cupro-Nickels.—Cupro-nickels containing 20, 30 and 45 per cent. of nickel are sometimes used for decorative castings, chemical castings and castings to resist sea-water. Their strengths are not as high as Monel, and in cases where a cast cupro-nickel is required, it is often preferred to use the more easily cast and cheaper nickel-silvers.

Nickel-Copper-Tin Alloys.—The nickel-copper-tin group of alloys, containing usually between 20 and 60 per cent. nickel and 5 and 15 per cent. tin, with and without appreciable quantities of zinc, iron and sometimes lead, aluminium, chromium and silicon, is practically standard for steam-valve parts, and is also used for bearings under corrosive and bad-lubrication conditions. These alloys show a high hardness, which is largely retained at steam temperatures, and good resistance to steam erosion and corrosion. They are somewhat brittle but, like silicon-containing Monel, resist metallic abrasion or galling. Silicon has a powerful hardening effect in the alloys, and in fact with silicon present lower tin contents can be used to give comparable hardnesses. The presence of 5 per cent. of lead gives a useful bearing alloy. The compositions used are numerous, and hardness ranges from 200 to 450 are obtainable by correct adjustment of the alloying constituents.

Nickel-Chromium and Nickel-Chromium-Iron Alloys.—There are two standard types of high nickel alloys in this category, *viz.*, the 80:20 nickel-chromium alloy and the alloy having as a base 60 to 70 per cent. nickel and 10 to 15 per cent. chromium, the balance being iron. Their outstanding characteristics are oxidation-resistance and strength at high temperatures. Without electric-melting equipment they are not easy to handle in the foundry, although small quantities can be made in good coke-fired pit furnaces. A tensile strength of 32 tons per sq. in. is obtained in a nickel-chromium-iron alloy falling in the range given above. Their principal applications are for furnace parts, and under correct conditions they can be used at temperatures up to 1,150 deg. C.

TABLE VI.—*Physical Properties of Copper Nickel Alloys.*

Alloy.	M.S. Tons sq. in.	E. per cent. on 2 in.	B.H.N. 2-mm. ball. 40 kg. 30 secs.	Spec. resistance. Microhms per cm.
90:10 Copper-nickel chill cast	16.1	52	75	14.8
90:10 Copper-nickel sand cast	12.8	17	62	15.0
96:4 Copper-nickel chill cast	14.2	50	64	7.4
96:4 Copper-nickel sand cast	11.6	22	61	8.3

Nickel-Molybdenum-Iron Alloys.—For resisting hydrochloric acid a group of alloys has been developed with a nickel-molybdenum-iron base, under the name of "Hastelloy." The following are the compositions and hardnesses of various grades of Hastelloy "as sand cast."

Hastelloy "A" ..	Nickel ..	60 per cent.
	Molybdenum ..	20 "
	Iron	20 "
	Brinell hardness	262.
Hastelloy "C" ..	Nickel ..	58 per cent.
	Molybdenum ..	17 "
	Iron	6 "
	Chromium ..	14 "
	Tungsten ..	5 "
	Brinell hardness	217.

A further alloy for the same purpose but not containing molybdenum is Hastelloy "D."

Nickel	85 per cent.
Silicon	10 "
Copper	3 "
Aluminium	2 "
Brinell hardness ..	364.

These alloys are likely to find an extending use, particularly for pump parts.

Miscellaneous Nickel Base Alloys.—Whilst there are innumerable casting alloys with a nickel base, there is only one further type to be mentioned here, the very hard facing alloy produced in America as "Colmonoy" No. 6. This alloy is being used for a type of construction which is being rapidly developed, namely, the building up of metals by depositing an alloy from a welding rod, essentially a casting process. Colmonoy No. 6 contains 75 per cent. nickel, chromium and boron. As deposited or cast it has a Brinell hardness number of 534 to 587, and is useful for producing hard facings on certain valve parts, etc., the hardness obtained being due to the presence of boride crystals.

TABLE V.—*Physical Properties.*

Alloy.	Sp.Gr.	Thermal conductivity, c.g.s. units.	Coefficient of linear expansion per deg. C. from 20 to 100 deg. C.	Patternmakers' shrinkage, in. per ft.
"Y"	2.80 (max.)	0.42	0.000022	0.155
R.R.50	2.73	0.415	0.000022	0.125
R.R.53	2.73	0.43	0.0000224	0.140
R.R.53C	2.73	0.415	0.000022	—
"Lo-Ex"	2.65–2.75	0.28–0.4	0.000019	0.048–0.084
"Birmasil Special"	2.65–2.75	—	0.000019	0.156
"P.2"	2.7–2.9	—	—	—

The information contained in this Paper has been derived from a wide range of sources, and whilst it has not been possible to refer individually to these a general acknowledgment is made of the help received in its compilation.

Alloying Cupola Grey Cast Iron

(*Concluded from page 527.*)

The addition of alloys to grey iron is by no means a "cure-all" for the foundryman's problems and should never be considered as such. Many thousands of tons of good, sound castings are being made with properly balanced mixtures that do not have alloy additions. At least 95 per cent. and probably more of the grey iron foundry production of America is straight grey iron, made under excellent supervision.

Enormous sums of money are being spent annually in the States and other countries in the addition of expensive alloys to grey iron castings when many times a really first-class well-balanced foundry pig-iron as a base for the mixture is much better suited.

Table III shows the more commonly used alloys and may be of some help to the foundryman in determining the weight of the alloy to use. It should be remembered that the greatest alloy recovery is to be associated with the hottest iron and by using large mixing ladles.

The Production of Ingot-Mould Castings*

By R. BALLANTINE

MR. R. BALLANTINE.

I.—SUMMARY OF DEVELOPMENTS

Considerable interest has been aroused in recent years in the subject of ingot-mould castings for use in steelworks, and when Swinden and Bolsover,[1] in a Paper presented to the Sheffield Conference of the Institute of British Foundrymen in 1935, put forward data of inestimable value and importance, the steelmaker's case was admirably presented. Arising from the discussion which followed, it was felt by foundrymen that a Paper of a practical nature showing developments in the production of ingot-mould castings would allay the fears of the steelmakers and prove that research and progress in this branch of foundry work are moving forward as rapidly as in other phases of foundry activity.

Those foundrymen trained in other branches of ironfounding naturally visualise the manufacture of ingot-mould castings as being very simple. They are, apparently, heavy pieces of metal of simple design, with uniform sections, in the manufacture of which one might expect ease in every operation; they seem, in fact, from the foundry point of view, to be all that one could wish for. Yet "things are seldom what they seem."

In the first place, these castings must conform to definite standards, and are subject to exacting service. They must withstand extreme variations in temperature and heavy usage, especially when "stickers" require removal. They must be sufficiently strong to undergo hose spraying with water, for cooling when exceptionally hot, and coupled with these qualities the internal finish must be good. The quality of the skin on the inside is important, and has a direct bearing on the ultimate lives of ingot moulds.

Mould Types

Two types of moulds are manufactured:—(1) The common or ordinary; and (2) the inverted. In the first type the top area of the mould is smaller than the bottom, and in the second the top area is larger, as shown in Fig. 1. The 5½-ton mould drawing on the left is that of a common mould with semi-closed top, and the 14-ton mould on the right is of the inverted type. Designs are extremely varied in both cases, and range from the square and rectangles to fluted octagonals and duodecagonals.

Cores

From the summary already given, it will readily be agreed that first-class cores are essential in this type of work. Starting from the shake-out, castings remain inside the foundry from two days to over a week, according to size and weight, so that early chilling of the casting is avoided. Fig. 2 shows a composite sketch in that it gives the lay-out and assembly of the mould and core in part section. A detailed description of core manufacture is essential. The corebox, either in wood or iron, is placed on the jolter, and a bottom lifting plate put in position. The bottom plate takes the contour of the core shape, allowing a slight clearance, an adjustable lifting rod or rods being carried to the top. A suitable tube is then slipped over, and filling with sand commences. Horizontal grids are placed at intervals as shown at A; these are comparatively light in section and made of steel for re-using. From four to six grids are inserted according to the height of the mould. Frequently, if the body of sand be large, an auxiliary row of short metal cuttings 6 in. long is inserted at the corners and between the gratings.

When the core-box is filled with sand, the jolting operation begins. Using 90 lbs. per sq. in. pressure a definite fall in sand is registered. The filling and subsequent operations are repeated, but prior to the finishing jolt, ashes are inserted inside the tube before it is removed. The effect is most beneficial, and the sleeking action of withdrawing the tube is overcome by settling the ashes with a final jolting. The corebox is slightly opened after a top hand ramming is given, and either the core or the box is removed, dependent on the mould type.

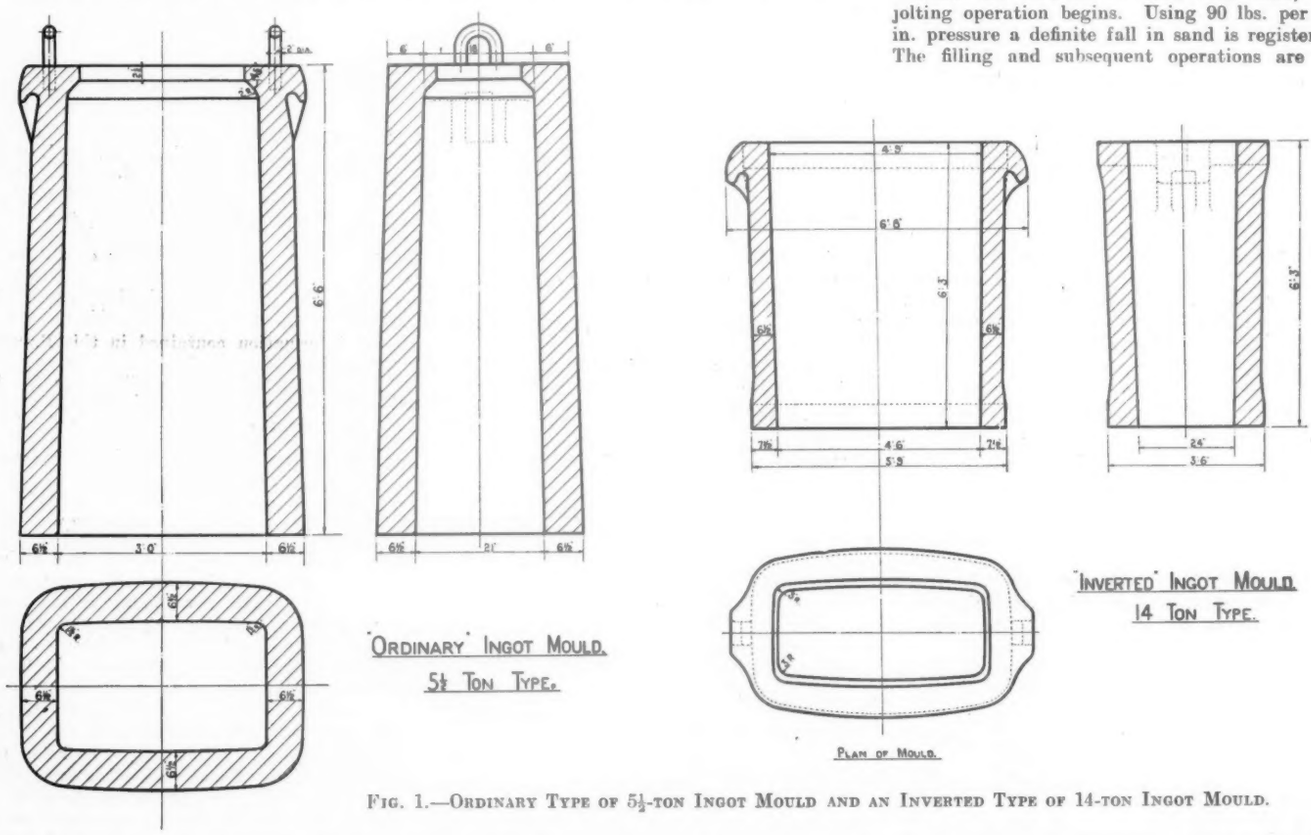


FIG. 1.—ORDINARY TYPE OF 5½-TON INGOT MOULD AND AN INVERTED TYPE OF 14-TON INGOT MOULD.

* Paper presented to the thirty-fourth Annual Conference of the Institute of British Foundrymen held in Derby from June 8 to 11, 1937.

1 Proceedings, Institute of British Foundrymen, Vol. XXVIII, p. 192.

Fundamentals for Core Production

There are certain features in core manufacture for this class of work which should be noted if satisfactory castings are to be produced:—

(1) The sand must be permeable, otherwise flaking in the corners occurs in the larger moulds, due to back pressure into the mould cavity. Ordinarily, release of gas should be through the core into the ashes, gas escaping as the metal rises. The artificial pricking of corners does not appeal as a means to assist venting or to counteract the scaling in corners. Were it convenient to do pricking from the inside of the core to the corners, then the advantages would be apparent.

(2) A liberal coating of blackwash eliminates the tendency to fuse where there are heavy metal thicknesses.

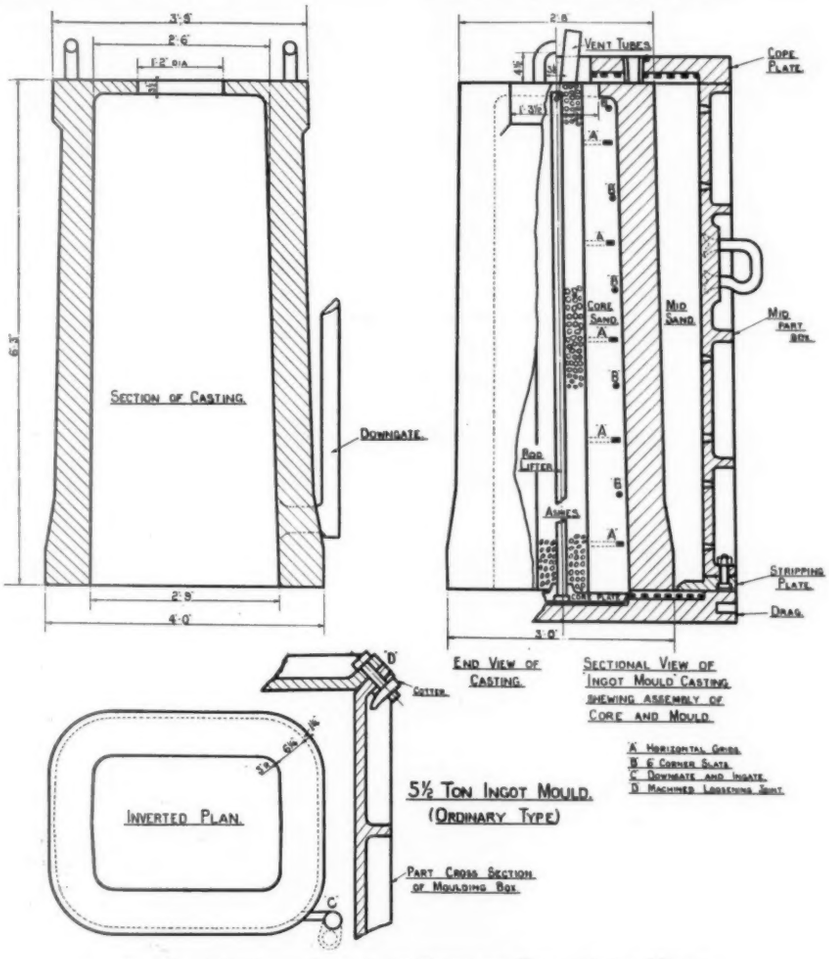


FIG. 2.—COMPOSITE SKETCH OF ORDINARY TYPE 5½-TON MOULD.

(3) It has been proved in practice that if these cores be dried throughout, the best results are not obtained. Cores dried inside are usually overheated on the outside. Consequently, a curling on the caked blackwash occurs, leaving indentations which must be levelled in the finished casting.

It is the author's experience that cores manufactured with a minimum of handling, and a minimum of disturbance in transit, give the best results. More trouble is caused by strains set up in the cores when in their green state, prior to entering the stoves, than is credited.

Moulding Boxes

The question of satisfactory moulding boxes is most important, and considerable experiments in design have been carried out. The mid-parts are made up of four separate plate castings with all joints machined. The perpendicular flanges are angled to 45 deg. Three of the corners are bolted, and the fourth is held by cotter bolts. This method releases strains and facilitates removal of the casting. A machined stripping plate is fixed to the underside of mid-parts, and is in two parts, split at alternate corners. This ensures carrying of the mid-part sand, and has the advantage of being easily replaced in case of alteration to design.

Gating and Feeding

All ingot-mould castings are run by downgates, and the in-gates are formed in the mid-parts. Top pouring by pencil gates has been discarded in favour of the former system. Opinions are divided as to the best methods of running any casting, but the author's experience is that for this type of work made in dry sand the results show much cleaner tops and internal surfaces than by the drop-gate method.

The metal thicknesses in ingot-mould castings are reasonably uniform, and it would appear that the necessity for feeding does not arise. An examination of fractured mould castings reveals an open metal structure in place of a denser structure in the wall centre. When expansion of the mould takes place in service, it is very probable that the initial shock of rapid change in temperature is counteracted by a resilient or cushioning effect resulting from this phenomenon. This effect possibly tends to hasten the crazing of internal surfaces, but, at the same time, it lessens the possibility of discards by major cracking and consequent losses through split ingot moulds in service.

Analysis and Usage

So much has been written about analysis for the ideal ingot mould, that it is with a certain amount of hesitancy that this subject is introduced. Careful scrutiny of the various investigators' findings leaves the author looking for some definite indication of analysis. Equally good lives have been obtained from ingot-mould castings with fairly wide variations in composition.

Swinden and Bolsover[2] give: T.C, 3.5 to 3.75; C.C, 0.3 to 0.6; Si, 1.9 to 2.3; Mn, 0.6 to 1.0; S, 0.03 to 0.05, and P, 0.03 to 0.045 per cent. They state in addition there is a tendency to limit the silicon to 1.7 or 1.9 per cent. with a higher manganese content of 0.9 to 1.1 per cent.

Other investigators, including Legrand, Shiokawa, Hruska, Léonard, Shaw and Blakiston, confirm the view that fairly wide variations are permissible, and this coincides with the author's view. Silicon at 1.8 per cent. and manganese not exceeding 0.9 per cent., with minimum sulphur and phosphorus, give good results. Blakiston, in a Paper[3] he presented to the Middlesbrough Branch of the Institute, advocated the need for research on the actual manufacturing side. He also suggested that, as an initial step, the internal core barrel should be eliminated. The author fully agrees with the statement regarding rigid core barrels.

Two objectionable features still have to be considered, for if the barrels are left in the cores, strains are set up in the casting when cooling; alternatively, if they be removed the red-hot ingot-mould castings must be handled roughly to remove the internal barrel. On the other hand, a sand and ash centre core with a minimum of iron reinforcements allows for easy contraction of the casting, and compression of the core takes place, but as a unit. The ash centre relieves the sand compression when contraction takes place. It is felt that the method of manufacture coupled to subsequent use in the steelworks has a greater bearing on the lives of ingot moulds than that of analysis. In addition, the salvage value to the steelworks of discarded ingot-mould castings must be considered.

Design of Moulds, Weight Ratios and Lives

No attempt will be made in this essentially practical Paper to summarise design, weight ratios and lives. There is such diversity of opinion in the various steelworks, all ably backed by actual experience, that definite standards in design are difficult to obtain. A mould design may be most satisfactory from a foundry point of view, but not suitable for producing a satisfactory rolling ingot. Again, there is experience of certain ingot-mould castings with objectionable features in design, as affecting the foundry, which give first-class rolling ingots and splendid lives.

An example of the variation of life of ingot moulds can be cited. Ingot mould castings, weighing approximately 8 tons, for producing standard slabs, were sent to two steelworks. The design was standardised, the analyses within limits were similar, and the castings were taken from common stock. In the case of works A, there was an average life of 55 heats, and an individual life of 62—a very consistent record. On the other hand, works B obtained an average of 110 heats, with individual lives as high as 176 from similar castings. In this instance the foundry cannot be questioned, and in fairness neither can the designer nor the metallurgist. One must look for something appertaining to local conditions in the steelworks to provide a solution.

Good ingot-mould lives can be obtained by a combination of three vital factors:—(1) In the foundry, by having good coremaking practice, and by paying attention to apparently trivial safeguards; (2) in the design, by having a safety margin in wall thickness, and (3) in the steelworks, by having reasonable attention and usage. The lives of ingot-mould castings have increased very rapidly in recent years. At works B, for example, within the last 10 years these same 8-ton ingot moulds have risen from average lives of 43. Better metal, better treatment in steelworks, modified designs, co-operation, and improved foundry technique, all add their quota towards better lives from these castings.

2 *Loc. cit.* 3 FOUNDRY TRADE JOURNAL, February 28, 1935, p. 153, and March 7, p. 175.

II.—ADDITIONAL DATA ON THE MANUFACTURE OF INGOT MOULDS

The foregoing summary explains in general the author's previous Paper,[4] "Recent Developments in the Production of Ingot Mould Castings." A continuance of this Paper will provide greater attention to manufacturing detail and dwell more fully on results of observations in practice.

Alternative Methods

The author has given a great deal of thought to alternative methods of production, and also to the materials used. It is common practice in many works to ram moulds and cores for producing castings up to 10 tons in dry sand, either by hand or pneumatic rammer, but exceeding this weight a transfer to the loam method is generally adopted. In America the trend would appear to be in favour of cement-bonded sands, as instanced by the Valley Mould Company adopting the Randupson process. This system has much to commend it, but it is questionable if a complete change-over would make for greater economies, in speedier production, and the ultimate lives secured.

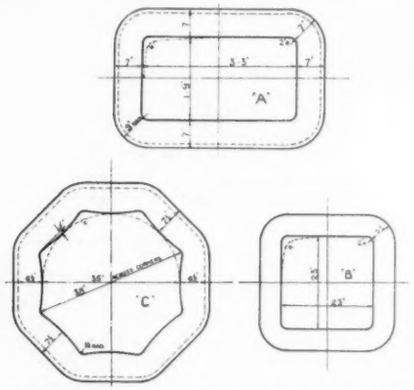


FIG. 3.—TYPES A, B AND C. THE CORE HARDNESS IS INDICATED AT DOTTED LINE X.

At the Mossend Works of the Fullwood Foundry Company all moulds and cores are produced in sand, and machines are exclusively used for jolting castings up to 20 tons. In excess of this weight pneumatic rammers are introduced, and in analysing the desirable features in the respective systems, it is the author's opinion that the latter practice has many advantages.

Ramming and Jolting

Hand ramming of cores and mid parts cannot be compared to jolting by machines, either for speed or consistency. Controlled preparation of sand by mechanical means has undoubtedly contributed to the fine results obtained. Jolting treats the mass sand as a unit, whereas hand ramming is a localised movement. The former method ensures a minimum variation in density, and Fig. 3 indicates where these variations occur in the core sections:—(A) Rectangular, (B) square and (C) which is fluted, may be either octagonal or duodecagonal. All show similar characteristics with the degree of hardness indicated by dotted lines (X).

The slight variations referred to do not affect the resultant casting in any way. There is definite danger, however, if a sand be used which has a low permeability. Whilst, it may be argued, uniformity is not accomplished even by jolting, one can easily bring to mind the many hard and soft ramming oddities which passed under the name of cores or moulds when relying on the human element.

It is frequently said that the skilled artisan will produce a casting second to none when properly rammed, but this is a mechanical age. The advent of the engineer to the foundry has revolutionised practice generally, and to a very great extent in the quantity production of ingot moulds.

Hot Tears

Hot tears in ingot moulds can be definitely traced to two causes:—(1) Fins; and (2) contraction. These two objectionable features have a direct association with each other. Fig. 4 shows an inverted type mould in section; the right hand view shows in detail the effect of both internal (core) fins (A) and external (mid part) fins (B). The placing of a loam stamp (C) which can be limited, but, unfortunately, cannot be eliminated, must be curtailed. Common practice is to place the stamp on the core some distance from the edge. The reason put forward by the practical moulder for this position is that moisture is absorbed by the dried core if placed at the edge; consequently, softening of the core is the result. Naturally, he anticipates crushing when placing the cope in position when closing, and this is quite a reasonable precaution from the moulder's viewpoint, but hopelessly wrong when the casting is examined. Fig. 5 shows part section of what actually happens. Both fins set very rapidly, especially when hematite irons are used. The free movement of the casting is restricted when initial expansion and natural contraction takes place.

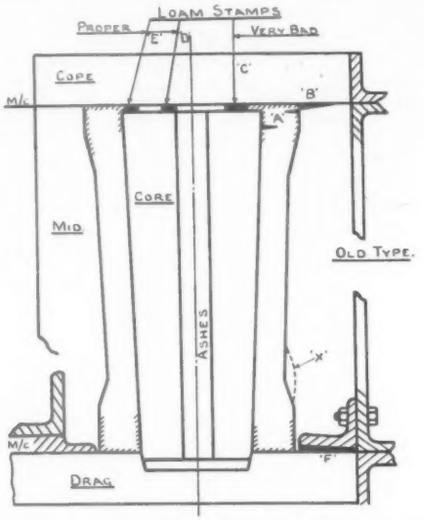


FIG. 4.—SHOWING HOT TEARS, IMPROPER LOAM STAMP AND FINS.

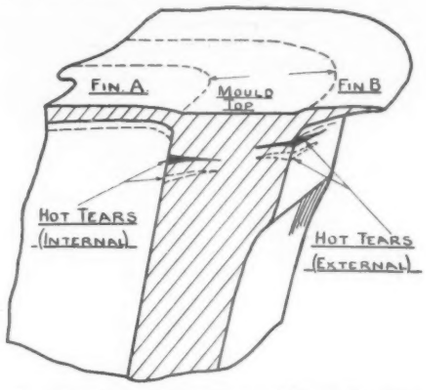


FIG. 5.—PART SECTION OF A MOULD CASTING AFTER COOLING.

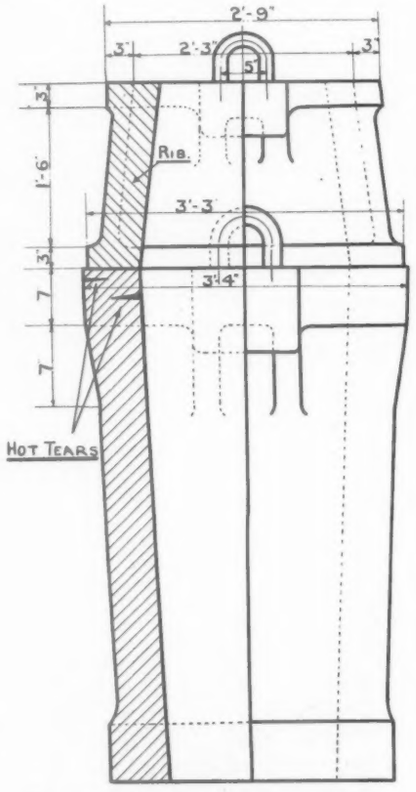


FIG. 6.—INVERTED MOULD WITH HEAD.

The core, being top heavy, allows the casting to ease from the core and settle downwards, but the fins definitely curtail this movement, as Fig. 5 indicates. It is obvious that the heavy body of metal is suspended, and results in the weak points taking the strain and the formation of hot tears. These defects move horizontally, not exactly uniformly, but at distances comparable with fin thicknesses. When it is borne in mind that inverted moulds have head boxes laid on top of them in steelworks practice, as shown in Fig. 6, the problem of internal hot tears becomes serious. Added top pressure makes the steel more searching and the hot tear full of free graphite is attacked, damaging the mould and eventually causing "stickers."

It is admitted that the machining of these mould castings will ensure freedom from these defects, and various machining allowances, varying from five to ten inches, are recommended, yet is one sure these after operations are essential when it is known that sound castings can be produced without hot tears? The left hand portion of Fig. 4 indicates how internal hot tear defects can be avoided. A loam stamp, restricted in quantity, is placed at the edge of the core. After the cope has been removed, the surplus loam is trimmed off and slightly bevelled. Another loam stamp is placed internally so that any percolation of metal will not enter the ash centre. This ensures a double check. Contraction of the casting is not impeded, because the loam stamp responds to the slight bevel.

External (mid part) fins B are objectionable. The necessity for under level finishing of sand to avoid crushing can be eliminated when machined boxes are used. Nevertheless, it is surprising how often this moulder's *trait* for safety is encountered despite the provision of machined boxes. A continual source of trouble is loam stamping. At (F) in Fig. 4 the mid part is shown on the drag. The very irregular angle plates used for supporting mid part sand, coupled to the black face of the boxes, may mean loam stamping to a depth of over an inch when closing. Steam gathers at X, softening the mould face, and subsequent scabbing occurs. The obvious remedy is machined boxes, as shown in Fig. 2.

(To be concluded.)

[4] Read before the Lancashire Branch of the Institute of British Foundrymen, December, 1936.

Stand at The British Industries Fair, 1937

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TOTAL CARBON	2·70%
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TOTAL CARBON	2·60%
SILICON	·75%
MANGANESE	·50%
SULPHUR	·05%
PHOSPHORUS	·06%

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This Week's News in Brief

Trade Talk

The Renishaw Iron Company, Limited, have restarted their No. 1 blast furnace, which has been relined.

Tenders are being invited for the erection of pithead baths at Fishburn Colliery, Ferryhill, Co. Durham.

Employees of Cruikshank & Company, Limited, of Denny Ironworks, were taken on a cruise to Arran last Saturday.

Smith & Grace, Limited, ironfounders, Thrapston, Northants, are in future to pay their employees a full week's wages for the annual August holiday period.

The North British Locomotive Company, Limited, Springburn, Glasgow, has secured a contract for the construction of eleven locomotives of the Pacific type for the Federated Malay States Railways.

The address of the London office of A. C. Wickman, Limited, will be Thames House, Millbank, London, S.W.1. The telephone number is Victoria 4383 and the telegraphic address "Autosella, Sowest, London."

Members of the Manchester Association of Engineers, by kind invitation of Craven Bros. (Manchester), Limited, and of Mr. R. Greenwood, chairman and managing director, are to visit the works of Craven Bros. at Reddish on Saturday, July 10, 1937, at 2.30 p.m.

The directors of the United Steel Companies, Limited, have offered assistance to the Social Organisation of their Cumberland group in building a new welfare hall. The firm have offered a donation of £2,500 and a loan of £2,500 to be secured by a mortgage.

The British Oxygen Company, Limited, have acquired from the Aberdeen Harbour Board premises which are to be used for the supply of oxygen, dissolved acetylene, calcium carbide, and accessories for oxy-acetylene cutting, and the vaporising of oxygen sent to Aberdeen in liquid form.

Foundry workers, at a meeting in Swansea last week, approved the employers' offer for an increase of 7½ per cent. on the gross weekly earnings, which on the craftsmen's base rate of 70s., means an increase of 5s. 3d. per week, and on the non-craftsmen's base rate of 52s. 6d., means an increase of 4s. per week.

Four workmen lost their lives, and ten others were injured at Corby recently, while at work on the blast-furnace plant of Stewarts and Lloyds, Limited. One of them was seen to collapse, apparently affected by fumes. Three of his fellow workmen went to his aid and lost their lives. The other ten were not seriously affected.

Negotiations opened during the present visit of the Russian trade delegation to Clydeside are expected to lead to the placing of orders worth at least £1,000,000. Machine tools and engineering products are what Russia wants most of all at present. There is also a possibility of shipbuilding contracts being placed.

At a meeting of the Joint Industrial Council of Newbie Engineering Works, Annan, last week, Mr. R. R. Stokes, managing director of the firm, intimated that the directors wished that every employee should share in the present boom conditions and that all employees would receive 47 hours' pay at their time rates, and the members of the staff one week's pay.

Mr. J. E. Hurst, of Darlaston Blast Furnaces, Darlaston, Staffs, will be pleased to hear from those who intend participating in the luncheon to be held at the George Hotel, Lichfield, prior to the cricket match between the Institute of British Foundrymen and the Works Managers' Association, in order that proper provision can be made. Tea will be served through the generosity of a few friends. It should be particularly understood that every member of the Institute is cordially invited to bring a party along.

Two more blast furnaces have been started in the Tees-side district, one at the Cleveland works of Dorman, Long & Company, Limited, and the other at the Seaton Carew ironworks of the South Durham Steel & Iron Company, Limited. There are now 34 blast furnaces in operation on the North-East Coast, compared with 29 a year ago. The furnace at the Cleveland works will be used for the manufacture of hematite iron, while the Seaton Carew furnace will be engaged on the production of basic iron for the steelworks.

The interests of David Brown Tractors, Limited, and Harry Ferguson, Limited, have been combined, and a new company is about to be formed, with a capital of £100,000. The joint managing directors will be Mr. David Brown, who is also the managing director of David Brown & Sons (Hudd.), Limited, and Mr. Harry Ferguson, the inventor of the Ferguson farm machinery. The new arrangement will enable Mr. Harry Ferguson to concentrate on technical development, while Mr. David Brown will be responsible for all commercial matters, including sales and production. This fusion of interests has been necessary to facilitate the rapid expansion required to cope with the demand for this new farm machinery, and will provide for works and plant additions.

At meetings held in Berlin to discuss the future of the International Ferro-Silicon Syndicate, which expires on June 30, it was decided to prolong the existing agreement to the end of July to permit decisions to be reached on various outstanding points, particularly the question of price control. Official quotations of the Syndicate have not been changed during the last few years, although costs of production have advanced, and producers, principally those in Sweden, now suggest that corresponding price increases might be made. An all round increase in prices would, it is believed, result in various difficulties, not only in marketing, but also as regards the self-supply of constituent works. There appears to be a certain measure of support among members of the Syndicate for the dissolution of the organisation, so as to give complete freedom to incorporated producers in respect of both production tonnage and prices.

Personal

Mr. Robert Smith, who is employed by Alex. Shanks & Son, Limited, Dens Ironworks, was severely injured in a works accident at Peterhead last week.

Mr. Frank S. Russell, chairman and managing director of General Refractories, Limited, is leaving for the United States on a tour of American refractories works. He will return about the end of July.

Mr. W. W. MacArthur, general manager of Sir W. G. Armstrong, Whitworth & Company, Limited, Scotswood, Newcastle-upon-Tyne, has been appointed general manager of Blackburn Aircraft Company, Limited, East Yorkshire.

Mr. H. N. Bassett, chief chemist of the Egyptian State Railways for the last ten years, will be available for another post when his present contract expires in the near future. He will be in England for a few days in July before leaving on a pleasure trip to the Argentine. He will return to England about the end of September until the middle of October. Whilst in this country his address will be c/o H. H. Chilton, Esq., The Manor, Willenhall, Staffs.

Wills

Hodkin, Arthur, director of Greenside Foundry Company, Limited, ironfounders £23,071

Shotton, Charles, of Smethwick, a director of Shotton Bros., Limited, ironfounders, of Oldbury £10,356

Allday, Percy William, of Solihull, chairman of William Allday & Company, and a director of Allday & Onions, Limited, engineers, of Small Heath £15,036

Obituary

Mr. Thomas Richard Grimwood, a director of the Enamelled Metal Products Corporation (1933), Limited, has died at the age of 76.

Mr. W. W. Butler, President of the Canadian Car & Foundry Company, Limited, has died in Montreal, aged 74. During his career Mr. Butler has been director of the American Steel Foundries, and established the Dominion Steel Car Company's plant in Montreal.

Progress Report

Although on first impression the time of seven working days seemed considerable, the organisers of the International Foundry Congress in Paris proved themselves wise in having allowed ample time in a city so large as Paris, so full of distractions, and in particular offering this year the great Exposition Internationale. It would be idle to deny the disappointment of visitors at its incomplete and unfinished state, but a tribute must be paid to this typically French conception, in which a large area of Paris, including a stretch of the river and some of its most important bridges, are enclosed and given over to the Exhibition. Probably only Parisians can say whether this is done without serious disturbance to the daily life of the city or not. The British party travelled on the outward journey with the Lord Mayor of London, going to open the British Pavilion, to help in completing which a group of British workers had been hurriedly taken across. It was formally opened on Saturday, June 19, but the visitors were unable to gain any impression or to compare it with the Russian and German buildings, because, although "opened," it was not open to inspection.

The work of the Congress went according to plan and technical sessions were held, as was a meeting of the International Test Bar Committee and two other international committees. The closing days were given over chiefly to further technical sessions and visits. The weather was fine on the whole, and the taxis appeared to go faster than ever. The British party is a representative group, headed by the new President, Mr. C. W. Bigg, and undoubtedly found the time well spent.

Company Reports

Greenwood & Batley, Limited.—Ordinary dividend for the year to March 31 of 7 per cent.

British Oxygen Company, Limited.—Half-year's dividend on the 6½ per cent. cumulative preference shares.

Laurence, Scott & Electromotors, Limited.—Dividend on the 5 per cent. £1 cumulative redeemable preference shares for the half-year to June 30, 1937.

Edgar Allen & Company, Limited.—Profit for year ended March 31, after providing £20,000 for taxation, £54,756; brought in, £23,762; preference dividend, £11,437; dividend on the ordinary shares of 7½ per cent., £16,160; to general reserve, £12,500; staff pension fund, £5,000; carried forward, £33,420.

Electric Construction Company, Limited.—Profit for year ended March 31, after providing for debenture interest and depreciation, £60,366; brought in, £16,181; preference dividend, £4,395; dividend of 10 per cent. on the ordinary shares, £30,000; employees' superannuation fund, £2,500; dividend equalisation fund, £10,000; general reserve, £10,000; carried forward, £19,652.

New Company

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

A. N. Wilkinson & Company, Limited, Union Street, Rotherham.—Capital: £5,000. Iron and brass founders. Directors: H. Buckley, A. N. Wilkinson and W. Hetherington.

Contract Open

Cairo, July 31.—43,500 metres of spigot and socket cast-iron pipes, ranging from 2½ in. to 12 in. dia.; 35 cast-iron sluice valves, ranging from 6 in. to 12 in. dia., and 4 cast-iron non-return valves, ranging from 8 in. to 12 in. dia., for the Ministry of Public Works, Tanzim Department. The Department of Overseas Trade. (Reference T. 24,043/37.)

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YORKSHIRE SAND

Yorkshire Sand is of a synthetic nature, its production being under careful laboratory control. Perfect standardization is obtained with the various grades, suitable for light and the heaviest steel castings.

It is because of the refractoriness of the sand and of the toughness of the mould surface that castings made with Yorkshire Sand are distinguishable by their excellent finish.

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MANCHESTER OFFICE: 9, Albert Square, Manchester, 2. Telephone: Blackfriars 6130. Telegrams: "Genefax, Manchester." (Mr. S. G. Throssell.)

SWANSEA OFFICE: Metropole Chambers, Wind Street, Swansea. Telephone: 3680. Telegrams: "Genefax, Swansea." (Mr. D. Hood-Williams.)

CARDIFF OFFICE: 17, Windsor Place, Cardiff. Telephone: 5796. Telegrams: "Genefax, Cardiff." (Mr. F. E. Rutter.)

MIDDLESBROUGH OFFICE: Halifax Buildings, Exchange Place.
Telephone: Middlesbrough 3313. Telegrams: "Genefax, Middlesbrough.

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"During the 40 years I have been connected with Steel Foundry work, considerable changes have taken place. Away back, we had Steel Moulders' Composition, Old Crucible Pots, etc., and each works claimed to have its own 'secret' moulding composition. High Silica Sand has eliminated practically all these from many foundries and to-day we have your 'Yorkshire Sand' which acts almost like a chill, and leaves the skin of the casting blue-black and as clean as cast iron.

The hot steel lies quietly against the wall of sand, and often when the casting has been lifted out of the mould, the latter looks as if it could be used over again, just like a permanent mould."

Raw Material Markets

While producers in all districts continue to despatch heavy tonnages of iron and steel, there remains a large demand from home sources which must inevitably be neglected. Overseas consumers would willingly pay much higher prices for supplies than are obtained in the home market, but makers are adhering to their policy of meeting home orders before accepting fresh export business.

Pig-Iron

MIDDLESBROUGH. — Steelworks continue to take up a large proportion of the pig-iron output and any additional supplies that become available are readily used at the steel plants. The outlook is not a happy one as far as the general body of consumers is concerned. New business is based on No. 3 Cleveland G.M.B. at 101s. per ton in the Middlesbrough area, 103s. on the North-East Coast, 104s. in Falkirk and 107s. on Clydeside. No. 1 foundry iron is 2s. 6d. extra, while No. 4 foundry and No. 4 forge are 1s. less than the foregoing figures. Deliveries of hematite are of a hand-to-mouth nature and are likely to remain so for a considerable period. Outputs have generally been disposed of over the rest of the year, although some makers are less heavily committed. Export inquiries are having to be neglected, although overseas consumers offer to pay heavy premiums on the home prices, which are governed by the quotation of 123s. for East Coast No. 1—delivered Middlesbrough.

LANCASHIRE.—The pressure for deliveries in this area has increased as a result of better activity at the textile-machine makers' plants. Other centres of consumption also are taking up large tonnages, but deliveries are having to be carefully rationed and users cannot hope to have the whole of their requirements satisfied for some time to come. Special grades are also difficult to procure, while there is a pronounced shortage of hematite.

MIDLANDS. — Steady deliveries are being made against contracts, but supplies only account for part of the heavy requirements of the consumers. The outlook is difficult, as producers are unwilling to sell too far ahead and most furnaces have already disposed of their outputs. As a result, Continental material is being taken up at much higher prices than the home figures. Northants No. 3 foundry iron is quoted at 103s. 6d. for delivery in the second half of the year, with Derbyshire, Lincolnshire and North Staffordshire material at 106s., delivered locally. An additional 11d. per ton is invoiced if delivery into works is stipulated. Special irons are only available in small tonnages; low-phosphorus iron is quoted at £6 5s. to £7 5s., according to quality and position of the consumers' works, while refined iron is quoted upwards from about £8. Hematite production is well sold ahead and there is little for disposal on the open market. West Coast mixed numbers are quoted at £6 14s. 6d., and East Coast No. 3 at £6 13s. 6d. per ton, less 5s. rebate.

SCOTLAND.—Arrivals of iron from abroad have considerably relieved the pressure for supplies; but this is merely a temporary phase, and, unless further tonnages are forthcoming, the position will again become urgent, as home production is not nearly adequate to meet inquiries. No. 1 foundry is quoted at 115s. 6d., with No. 3 at 113s., delivered f.o.t. furnaces. No. 3 Cleveland iron is quoted at 104s. f.o.t. Falkirk and 107s. f.o.t. Glasgow. Hematite is quoted at 123s., British basic 107s. 6d. and Indian basic 100s. per ton, all delivered steelworks, less 5s. rebate.

Coke

Activity in the foundry-coke market continues unabated and orders have been placed with some producers for deliveries up to the end of the year, while, in other cases, makers refuse to accept orders involving deliveries after the end of September. For delivery in Birmingham and district, best Durham coke is officially quoted on the basis of 49s. 6d. per ton, but slightly more is being paid at times. The price of Welsh coke varies from 47s. 6d. up to 62s. 6d. per ton.

Steel

The features of the steel market are the continuous pressure on the part of the consumers to obtain deliveries against existing contracts and the difficulty of placing new business, says the official report of the London Iron and Steel Exchange. Many of the producers have sold their output until the end of the year and are unable to accept orders for any definite delivery. Heavy imports of steel-making pig-iron have relieved the immediate needs of the steelworks with regard to their raw materials. In the semi-finished steel section of the market, the scarcity of steel is severely felt. Arrangements have been made, however, by which it is hoped that all the consuming works will receive more regular supplies from British producers. There is a strong home demand for finished steel, but comparatively little new business is passing. Steelmakers have sold so far ahead that they are reluctant to accept fresh commitments, although production appears to be extending. There is an active export demand, but, in view of the heavy home requirements, only a portion of this can be satisfied.

Scrap

While the demand for iron and steel scrap generally remains on a heavy scale, some relief appears to have been afforded to the market by the arrival of large tonnages from abroad. As far as steel material is concerned, there can be little doubt that the control of sales has had the effect of releasing additional supplies. The steelworks continue to take up all available tonnages and there is still only a meagre tonnage for disposal on the open market. Pig-iron deliveries appear to have increased somewhat, especially in Scotland, and this also has helped to ease the position with regard to scrap.

Metals

Considerable weakness has been experienced at times in all the non-ferrous metal markets during the week, and liquidation has met with little resistance. Nevertheless, when selling has ceased, prices have shown an immediate tendency to recover partially. With regard to the trend in the immediate future, Henry Gardner & Company, Limited, in their weekly report, point out that, although the volume of trade appears to continue unabated, the fall in values, due to the rectification of an overbought situation, has, of course, wiped out speculative profits to a very great extent, both in commodities and shares, and, hence, it is more than likely that the present feature of caution and hesitation will continue for some time.

Copper.—The Board of Trade returns for the month of May reveal that imports of copper during that month were 35,901 tons, against 23,097 tons in May, 1936, while imports for the five months were 145,420 tons in 1937, against 120,923 tons in the corresponding period of last year. Exports also were higher at 13,673 tons in May of this year, as compared with 8,279 tons in May, 1936, while exports in the five months totalled 56,850 tons, against 39,297 in the first five months of 1936. A moderate demand has been experienced recently; world consumption is reported to be well maintained. Monetary difficulties in France, culminating in the resignation early on Monday morning of M. Léon Blum's "Popular Front" Government, naturally have had their effects on trade, while the continuance of the violent strikes in the United States has further upset commercial relations in that country. The Year Book published by the American Bureau of Metal Statistics indicates that world copper consumption for the years 1934, 1935 and 1936 was respectively 1,358,900, 1,629,400 and 1,879,900 metric tons.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £53 7s. 6d. to £53 10s.; Friday, £53 12s. 6d. to £53 15s.; Monday, £52 10s. to £52 12s. 6d.; Tuesday, £53 to £53 2s. 6d.; Wednesday, £55 7s. 6d. to £55 10s.

Three Months.—Thursday, £52 18s. 9d. to £53; Friday, £53 2s. 6d. to £53 5s.; Monday, £52 7s. 6d. to £52 10s.; Tuesday, £52 12s. 6d. to £52 17s. 6d.; Wednesday, £54 12s. 6d. to £54 15s.

Tin.—As a direct result of the strikes at the steel plants in the United States, activity at the tinplate mills has declined within the past few weeks from 105 per cent. of normal capacity to between 85 and 90 per cent. Other industries also are affected by labour disputes and the industrial outlook cannot be accurately gauged at present. As so often is the case, the strikes in America have come at a time when the plants have as much business as they can cope with, even when working to capacity. It is reported that the reduction in the rate of operations at the tinplate mills has reduced American consumption of tin by about 600 tons a month. It is understood that consumers in the United States are being criticised for not contracting for their prospective requirements for this summer, and there have been intimations that a hand-to-mouth buying policy will prove to be expensive.

The International Tin Research and Development Council announce an important revision in the tin statistics published in the Council's Bulletin for June, whereby they now include the quantities of tin smelted and consumed locally in such countries as Japan and Australia. This revision has been applied to the figures for past years, as well as for the current year, so that these statistics now cover practically the whole of the world's production and consumption of tin, excluding only the quantities refined and consumed locally in China, in respect of which no information is available. World statistics for the years 1934, 1935 and 1936 on the new basis are given as follow :—Production (tons), 114,881, 146,819, 178,226; consumption (tons), 122,790, 148,713, 162,738. Consumption in the year ended April, 1937, in comparison with the statistics for the previous year, was 173,683 tons, against 156,391 tons.

Official quotations were as follow :—

Cash.—Thursday, £246 15s. to £247; Friday, £246 to £246 5s.; Monday, £245 5s. to £245 15s.; Tuesday, £245 15s. to £246; Wednesday, £247 15s. to £248.

Three Months.—Thursday, £246 to £246 10s.; Friday, £245 10s. to £245 15s.; Monday, £244 10s. to £244 15s.; Tuesday, £245 to £245 10s.; Wednesday, £246 15s. to £247.

Spelter.—Dull and featureless conditions have continued to prevail in this market and there is little immediate prospect of any material improvement. Supplies of high-grade metal remain on the short side.

Daily market prices :—

Ordinary.—Thursday, £20 13s. 9d.; Friday, £20; Monday, £20 8s. 9d.; Tuesday, £20 12s. 6d.; Wednesday, £21.

Lead.—Exports of lead in May last were 10,757 tons, against only 2,889 tons in May, 1936. For the five months of 1937, exports totalled 30,606 tons, as compared with 19,221 tons in the corresponding period of last year. Imports at 28,489 tons in May of this year compare with 33,031 tons in the same month of last year, while imports for the first five months of 1937 and 1936 totalled 142,716 tons and 153,885 tons respectively. Business has again been quiet, but earlier in the week some buyers took advantage of the low quotations to re-enter the market for small tonnages. It is understood that British Lead Mines, Limited, with a capital of £50,000, has been formed to explore the lead resources of the United Kingdom

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £22 1s. 3d.; Friday, £21 8s. 9d.; Monday, £21 12s. 6d.; Tuesday, £21 18s. 9d.; Wednesday, £22 18s. 9d.

Catalogue Received

Industrial Furnaces. The receipt of Publication No. 8/8, issued by Stein & Atkinson, Limited, 47, Victoria Street, London, S.W.1, caused us to reflect that this was probably the first time that a serious piece of trade literature emanating from one of the internationally-known steelworks engineers had thought it wise to include more than an odd example or so of work carried out for the foundry industry. Whilst in the main, illustrated descriptions are given of gargantuan producers, melting and rolling mill and heat-treatment furnaces, much space is devoted to the annealing of steel castings, the melting of iron and non-ferrous metals by the oil-fired rotary furnace, and the handling of malleable annealing pots. In the past this type of concern was inclined to restrict its activities to iron and steel works plant, and we are sure that by embracing the foundry industry, a better load will be assured during the inevitable slack periods. The brochure runs to 40 pages and is splendidly illustrated.

ALUMINIUM ALLOYS FOR EVERY FOUNDRY REQUIREMENT

B.A. ALUMINIUM CASTING ALLOYS

Alloy designation	Chief alloying metals	Form of test specimen	Proof stress tons/sq. in.	Com. mercial elas. limit tons/sq. in.	Ult. tensile strength tons/sq. in.	Elongation % on 2"	Brinell hardness
3L5	2½–3% Cu. 12½–14½% Zn.	Sand cast	3·5– 4·0	5·0– 6·0	9·0–11·0	2·0– 4·0	60– 65
		Chill cast	3·5– 4·0	6·0– 7·0	11·0–14·0	3·0– 8·0	65– 70
4L11	6 –8% Cu.	Sand cast	3·5– 4·0	5·5– 6·5	7·5– 9·0	1·5– 2·5	60– 70
		Chill cast	3·5– 4·0	6·0– 7·0	9·0–11·5	3·0– 5·0	65– 70
3L8	11 –13% Cu.	Sand cast	4·5– 5·0	6·0– 7·0	7·0– 8·0	0· – 1·0	75– 90
		Chill cast	4·5– 5·0	7·0– 8·0	9·0–11·0	0· – 1·5	80– 90
BA/40D	10 –13% Si.	Sand cast, modified	3·5– 4·0	5·0– 6·0	10·5–11·0	5·0– 8·0	50– 55
		Chill cast, modified	4·0– 4·5	5·5– 6·5	13·0–14·0	8·0–15·0	55– 60
BA/40J	7½–8½% Si.	Sand cast	3·0–3·25	4·25–4·5	9·0–10·0	6·0–11·0	45– 47
		Chill cast	3·0–3·25	4·5– 5·0	11·0–12·0	13·0–20·0	47– 50
CS/16	4% Cu., 3% Si.	Sand cast	3·0– 3·5	5·0– 5·5	8·0– 9·0	2·[illegible]	[illegible]
		Chill cast	3·0– 3·5	5·0– 5·5	10·5–12·5	6·[illegible]	[illegible]
"Y" alloy	4% Cu., 2% Ni. 1½% Mg.	Sand cast, heat-treated	13·0–14·0	13·0–14·0	14·0–15·0	[illegible]	[illegible]
		Chill cast, heat-treated	14·0–15·6	16·0–18·0	18·0–20·0	2·0– 4·0	95–105
BA/23	1½% Mg.	Sand cast, heat-treated	10·5–12·0	11·0–12·5	12·0–13·0	2·0– 3·0	95–105
		Chill cast, heat-treated	11·5–13·6	12·0–13·5	16·0–17·5	12·0–20·[illegible]	70– 80
BA/40M	12% Si., 0·4% Mn. 0·3% Mg.	Sand cast, heat-treated	13·0–15·5	15·0–16·5			
		Chill cast, heat-treated	16·0–18·0				
BA/5	5–6% Cu.	Sand cast, heat-[illegible]					

DATA FOR THE FOUNDRYMAN

Will be gladly sent on request

THE British Aluminium CO. LTD

Head Office: ADELAIDE HOUSE, LONDON, E.C.4. Telephone: Mansion House 5561 & 8074 (6 lines). Telegrams: "Cryolite, Bilgate, London."

F.T.J. 24.6.37.

RAW MATERIALS—PRICE LIST

(Wednesday, June 23, 1937)

COPPER

	£	s.	d.
Standard cash	55	7	6
Three months	54	12	6
Electrolytic	61	0	0
Tough	62	2	6
Best selected	62	12	6
Sheets	93	7	6
India	74	17	6
Wire bars	62	17	6
Ingot bars	62	17	6
H.C. wire rods	67	7	6
Off. av. cash, May	61	4	8 1/16
Do., 3 mths., May	58	6	4 3/16
Do., Sttlmnt., May	61	3	5 1/16
Do., Electro, May	64	13	5 1/16
Do., B.S., May	65	0	0
Do., wire bars, May	65	13	1 1/16
Solid drawn tubes			14d.
Brazed tubes			14d.
Wire			10 1/4d.

BRASS

Solid drawn tubes	12 1/2d.
Brazed tubes	14 1/2d.
Rods, drawn	11d.
Rods, extd. or rlld.	7 1/2d.
Sheets to 10 w.g.	10d.
Wire	9 1/2d.
Rolled metal	9 1/2d.
Yellow metal rods	7 1/2d.

TIN

	£	s.	d.
Standard cash	247	15	0
Three months	246	15	0
English	247	15	0
Bars	250	0	0
Straits	249	0	0
Eastern	249	7	6
Banca (nom.)			—
Off. av. cash, May	250	16	11 1/16
Do., 3 mths., May	248	12	8 7/16
Do., Sttlmt., May	250	16	10 9/16

SPELTER

	£	s.	d.
Ordinary	21	0	0
Remelted	19	0	0
Hard	18	10	0
Electro, 99.9	23	10	0
English	21	17	6
India	19	10	0
Zinc dust	30	0	0
Zinc ashes	7	15	0
	23	4	6 13/32
	23	1	10 7/16

LEAD

	£	s.	d.
Soft foreign, ppt.	22	18	9
Empire (nom.)	22	13	9
English	24	15	0
Off. aver., May	23	18	10 37/32
Aver. spot, May	24	0	0

ALUMINIUM

Ingots	£100 to £105
Wire	1/3 to 1/4 lb.
Sheet and foil	1/2 to 1/4 lb.

ZINC SHEETS, &c.

	£	s.	d.	£	s.	d.
Zinc sheets, English	34	10	0 to 35	0	0	
Do., V.M. ex-whse.	34	10	0 to 35	0	0	
Rods				28	10	0

ANTIMONY

	£	s.	d.	£	s.	d.
English	82	10	0 to	83	10	0
Chinese, ex-whse.				69	0	0
Crude, c.i.f.				36	10	0

QUICKSILVER

	£	s.	d.
Quicksilver	15	5	3

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—			
25%	12 10 0 to 14 0	0	(nom.)
45/50%	10 15 0 to 12 0	0	(nom.)
75%	15 15 0 to 17 0	0	(nom.)
Ferro-vanadium—			
35/50%		12/8	lb. Va
Ferro-molybdenum—			
70/75% carbon-free		4/9	lb. Mo.
Ferro-titanium—			
20/25% carbon-free		9d.	lb.
Ferro-phosphorus, 20/25%		£21 to £22	
Ferro-tungsten—			
80/85%		5/-	lb. (nom.)
Tungsten metal powder—			
98/99%		5/1 1/2	lb. (nom.)
Ferro-chrome—			
2/4% car.	32 17 6		
4/6% car.	22 10 0		
6/8% car.	22 10 0		
8/10% car.	22 10 0		
Ferro-chrome—			
Max. 2% car.	32 10 0		
Max. 1% car.	35 15 0		
Max. 0.5% car.	36 10 0		
70% carbon-free	9 1/2d.	lb.	
Nickel—99.5/100%	£180 to £185		
"F" nickel shot	£165 0 0		
Ferro-cobalt, 98/99%	8/6	lb.	
Metallic chromium—			
96/98%	2/5	lb.	
Ferro-manganese—			
76/80% loose	£16 15 0 to 17 5 0		
76/80% packed	£17 15 0 to 18 5 0		
76/80% export	£20 0 0		
Metallic manganese—			
94/96% carbon-free	1/3	lb.	

Per ton unless otherwise stated, basis 2-ton lots.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	2s. 7d.
Finished bars, 18% tungsten	3s. 6d.

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under 1/8 in. to 1/4 in.	3d. lb.
Do., under 1/4 in. to 3/16 in.	1/- lb.
Flats, 1/8 in. × 1/4 in. to under 1 in. × 1/8 in.	3d. lb.
Do., under 1/8 in. × 1/4 in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

	£	s.	d.	£	s.	d.
South Wales (West)—						
Heavy steel, best	3	7	6 to	3	10	0
Mixed iron and steel	3	5	0 to	3	7	6
Heavy cast iron	3	8	0 to	3	10	0
Good machinery				4	2	6
Cleveland—						
Heavy steel, best	3	6	6 to	3	9	0
Steel turnings				2	15	0
Heavy cast iron				4	5	0
Heavy machinery				4	10	0
Midlands—						
Short heavy steel	3	15	0 to	4	0	0
Light cast-iron scrap				3	5	0
Heavy wrought iron	4	0	0 to	4	5	0
Steel turnings	2	2	6 to	2	5	0
Scotland—						
Heavy steel, best	3	4	6 to	3	7	0
Ordinary cast iron	4	7	6 to	4	10	0
Cast-iron borings	2	0	0 to	2	2	6
Wrot-iron piling	4	10	0 to	4	12	6
Heavy machinery	4	13	6 to	4	15	0

London—Merchants' buying prices, delivered yard.

	£	s.	d.
Copper (clean)	45	0	0
Brass	28	0	0
Lead (less usual draft)	17	10	0
Tea lead	11	10	0
Zinc	13	0	0
New aluminium cuttings	74	0	0
Braziery copper	39	0	0
Gunmetal	43	0	0
Hollow pewter	160	0	0
Shaped black pewter	115	0	0

PIG-IRON

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	83/6
,, No. 3	81/-
,, No. 4	80/-
Forge No. 4	80/-
Hematite No. 1	123/-*
Hematite M/Nos.	122/6*
N.W. Coast—	
Hem. M/Nos. d/d Glas.	123/-*
,, d/d Birm.	134/6*
Malleable iron d/d Birm.	160/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	83/-
,, No. 3 fdry.	86/-
Northants forge	80/6
,, fdry. No. 3	83/6
,, fdry. No. 1	86/6
Derbyshire forge	83/-
,, fdry. No. 3	86/-
,, fdry. No. 1	89/-
Scotland—	
Foundry, No. 1, f.o.t.	115/6
,, No. 3, f.o.t.	113/-
Cleveland No. 3, Glasgow	87/-
,, ,, Falkirk	84/-
Scottish hem. M/Nos. d/d	123/-*
Sheffield (d/d district)—	
Derby forge	80/6
,, fdry. No. 3	83/6
Lincs forge	80/6
,, fdry. No. 3	83/6
W.C. hematite	128/6*
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	89/-
Staffs fdry. No. 3	89/-
Northants fdry. No. 3	87/6
Cleveland fdry. No. 3	89/-
Glengarnock, No. 3	136/-
Clyde, No. 3	136/-
Monkland, No. 3	136/-
Summerlee, No. 3	136/-
Eglinton, No. 3	136/-
Gartsherrie, No. 3	136/-
Shotts, No. 3	136/-

* Subject to a rebate of 5s. per ton under certain conditions.

FINISHED IRON AND STEEL

Usual district deliveries for iron; delivered consumers' station for steel.

[A rebate of 15/- per ton for steel sections, plates and joists is obtainable in the home trade under certain conditions.]

Iron—	£	s.	d.	£	s.	d.
Bars (cr.)				11	17	6
Nut and bolt iron	10	5	0 to	10	15	0
Hoops				12	15	0
Marked bars (Staffs) f.o.t.				14	7	6
Gas strip				12	15	0
Bolts and nuts, 1/2 in. × 4 in.	17	10	0 and up.			
Steel—						
Plates, ship, etc.	11	8	0 to	11	10	6
Boiler plts.	11	18	0 to	12	0	6
Chequer plts.				13	0	6
Angles				11	0	6
Tees				12	0	6
Joists				11	0	6
Rounds and squares, 3 in. to 5 1/2 in.				12	0	6
Rounds under 3 in. to 1/4 in. (Untested)				11	9	0
Flats—8 in. wide and over				11	5	6
,, under 8 in. and over 5 in.				11	10	6
Rails, heavy				10	2	6
Fishplates				14	2	6
Hoops (Staffs)				12	4	0
Black sheets, 24g. (4-t. lots)				15	15	0
Galv. cor. shts. (,,)				19	10	0
Galv. flat shts. (,,)				20	0	0
Galv. fencing wire, 8g. plain				20	5	0
Billets, soft, 100-ton lots				7	17	6
Sheet bars				7	15	0
Tin bars				7	15	0

PHOSPHOR BRONZE

	Per lb. basis
Strip	12 3/4d.
Sheet to 10 w.g.	13 3/4d.
Wire	14 3/4d.
Rods	15d.
Tubes	20d.
Castings	16d.

Delivery 3 cwt. free.
10% phos. cop. £33 above B.S.
15% phos. cop £38 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3 1/2 to 1/9 1/2
To 15 in. wide	1/3 1/2 to 1/9 1/2
To 18 in. wide	1/4 to 1/10
To 21 in. wide	1/4 1/2 to 1/10 1/2
To 25 in. wide	1/5 to 1/11
Ingots for spoons and forks	9d. to 1/5 1/2
Ingots rolled to spoon size	1/- to 1/8 1/2
Wire round—	
to 10g.	1/6 1/2 to 2/1 1/2

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/5 1/2 upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	25.76
No. 2 foundry, Valley	24.00
No. 2 foundry, Birm.	20.38
Basic, Valley	23.50
Malleable, Valley	24.00
Grey forge, Valley	23.50
Ferro-mang. 80%, seaboard	102.50
O.-h. rails, h'y, at mill	42.50
Billets	37.00
Sheet bars	37.00
Wire rods	47.00
	Cents.
Iron bars, Chicago	2.40
Steel bars	2.45
Tank plates	2.25
Beams, etc.	2.15
Skelp, grooved steel	2.10
Steel hoops	2.40
Sheets, black, No. 24	2.40
Sheets, galv., No. 24	3.80
Wire nails	2.75
Plain wire	2.90
Barbed wire, galv.	3.40
Tinplates, 100-lb box	$5.35

COKE (at ovens)

Welsh foundry	42/6
,, furnace	36/-
Durham foundry	38/6
,, furnace	36/6
Scotland foundry	34/6
,, furnace	32/6

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes 20×14 per box	24/6 to 25/6
,, 28×20 ,,	49/- to 51/-
,, 20×10 ,,	34/6 to 35/6
,, 18 3/4×14 ,,	24/9 to 25/9
C.W. 20×14 ,,	22/- to 23/-
,, 28×20 ,,	45/- to 46/6
,, 20×10 ,,	31/- to 32/6
,, 18 3/4×14 ,,	23/- to 25/-

SWEDISH CHARCOAL IRON & STEEL

Pig-iron	£12	0	0 to	£13	0	0
Bars-hammered, basis	£20	0	0 to	£21	0	0
Bars and nail-rods, rolled, basis	£19	0	0 to	£20	0	0
Blooms	£16	0	0 to	£17	0	0
Keg steel	£27	0	0 to	£30	0	0
Faggot steel	£20	0	0 to	£25	0	0
Bars and rods dead soft st'l	£19	0	0 to	£20	0	0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 19.39 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

		£	s.	d.		
June	17 ..	53	7	6	dec.	2/6
,,	18 ..	53	12	6	inc.	5/-
,,	21 ..	52	10	0	dec.	22/6
,,	22 ..	53	0	0	inc.	10/-
,,	23 ..	55	7	6	,,	47/6

Electrolytic Copper

		£	s.	d.		
June	17 ..	60	0	0	No	change
,,	18 ..	60	0	0	,,	,,
,,	21 ..	59	10	0	dec.	10/-
,,	22 ..	59	10	0	No	change
,,	23 ..	61	0	0	inc.	30/-

Standard Tin (cash)

		£	s.	d.		
June	17 ..	246	15	0	dec.	20/-
,,	18 ..	246	0	0	,,	15/-
,,	21 ..	245	5	0	,,	15/-
,,	22 ..	245	15	0	inc.	10/-
,,	23 ..	247	15	0	,,	40/-

Tin (English ingots)

		£	s.	d.		
June	17 ..	247	0	0	dec.	20/-
,,	18 ..	246	5	0	,,	15/-
,,	21 ..	245	10	0	,,	15/-
,,	22 ..	246	0	0	inc.	10/-
,,	23 ..	247	15	0	,,	35/-

Spelter (ordinary)

		£	s.	d.		
June	17 ..	20	13	9	inc.	8/9
,,	18 ..	20	0	0	dec.	13/9
,,	21 ..	20	8	9	inc.	8/9
,,	22 ..	20	12	6	,,	3/9
,,	23 ..	21	0	0	,,	7/6

Spelter (Electro, 99.9 per cent.)

		£	s.	d.		
June	17 ..	23	5	0	inc.	8/9
,,	18 ..	22	10	0	dec.	15/-
,,	21 ..	22	18	9	inc.	8/9
,,	22 ..	23	2	6	,,	3/9
,,	23 ..	23	10	0	,,	7/6

Lead (soft foreign, prompt)

		£	s.	d.		
June	17 ..	22	1	3	inc.	2/6
,,	18 ..	21	8	9	dec.	12/6
,,	21 ..	21	12	6	inc.	3/9
,,	22 ..	21	18	9	,,	6 3
,,	23 ..	22	18	9	,,	20/-

Lead (English)

		£	s.	d.		
June	17 ..	24	0	0	No	change
,,	18 ..	23	10	0	dec.	10/-
,,	21 ..	23	10	0	No	change
,,	22 ..	23	15	0	inc.	5/-
,,	23 ..	24	15	0	,,	20/-

Imports and Exports of Pig-iron, Castings, etc., in May and the Five Months 1937, compared with May and the Five Months 1936.

	May.		Five months.		May.		Five months.	
	1936.	1937.	1936.	1937.	1936.	1937.	1936.	1937.
	Tons.	Tons.	Tons.	Tons.	£	£	£	£
Imports.								
Pig-iron—from British India	12,244	11,029	34,719	65,133	38,030	38,858	108,162	224,685
,, ,, Other British Countries	—	—	—	5,041	—	—	—	21,047
,, ,, Foreign Countries	8,795	13,464	18,278	32,105	35,918	78,117	84,318	187,245
Total	21,039	24,493	52,997	102,279	73,948	116,975	192,480	432,977
Castings and forgings	673	127	3,608	1,049	26,499	5,259	121,445	32,510
Cast pipes and fittings	99	75	544	416	4,083	2,571	20,055	11,904
Stoves, grates, etc.	79	48	302	258	8,501	6,974	34,243	36,646
Baths	561	1,026	2,810	4,260	13,916	25,027	70,946	101,984
Hollow-ware, all kinds	258	260	1,347	1,444	14,998	16,096	77,761	86,585
Exports.								
Pig-iron, forge and foundry	5,980	7,540	22,695	44,609	25,552	43,576	87,543	219,640
,, acid	1,941	5,971	14,279	26,644	6,984	33,967	49,389	138,608
,, basic	3	102	108	496	12	457	557	2,886
Total	7,924	13,613	37,082	71,749	32,548	78,000	137,489	361,134
Castings and forgings	379	385	1,944	1,422	13,152	14,041	69,137	52,282
Cast pipes and fittings, up to 6 in. diameter	5,537	6,331	23,437	25,223	65,325	65,105	263,011	266,904
,, ,, over 6 in. ,,	3,022	4,155	17,986	16,830	26,952	31,835	147,615	131,554
Stoves, grates, etc.	770	973	4,225	4,979	40,261	51,164	214,542	262,772
Sanitary cisterns	249	345	1,271	1,562	7,827	12,256	40,042	51,555
Bedsteads, including tubes therefor	385	607	2,067	2,544	14,611	21,340	77,179	94,254
Hollow-ware	529	391	2,255	2,218	16,330	14,959	78,190	76,656

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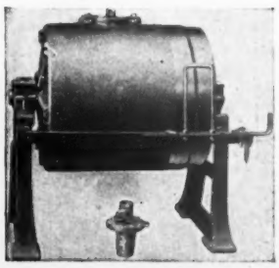

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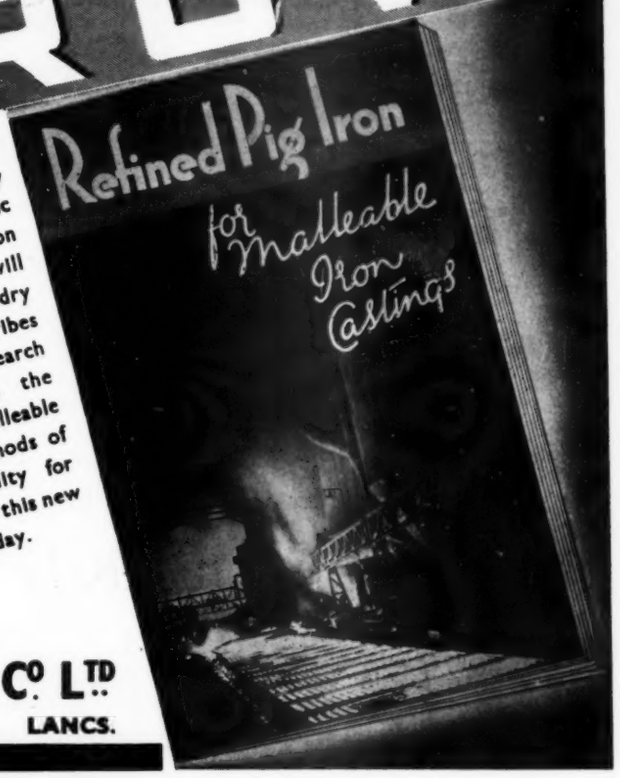

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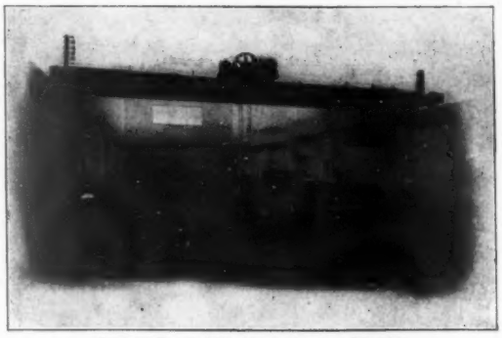

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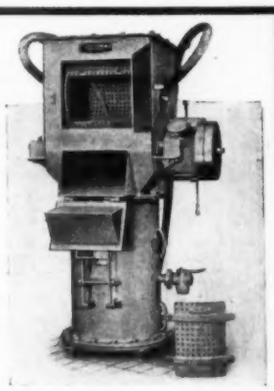

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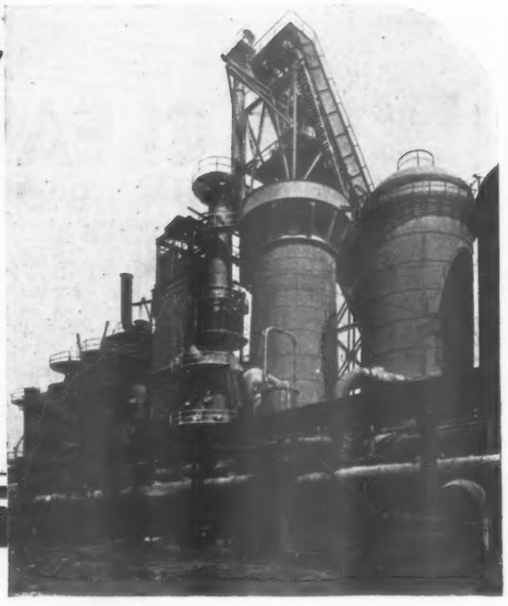

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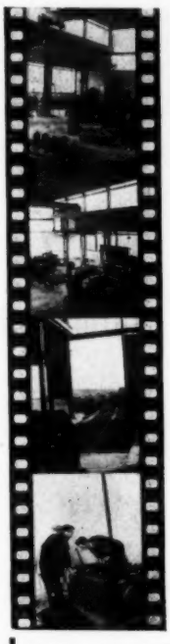

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